JPRS-USP-87-003
22 APRIL 1987

# USSR Report

## SPACE

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# USSR REPORT
## SPACE

## CONTENTS

SPACE APPLICATIONS

MANNED MISSION HIGHLIGHTS

BLAGOV COMMENTARY ON 'MIR' STATION, FIRST MANNING

Moscow ZEMLYA I VSELENNAYA in Russian No 6, Nov-Dec 86 pp 2-10

[Article by V.D. Blagov, deputy flight director, under the rubric "Space": "'Mir'--the New Generation Soviet Orbital Station"; first paragraph is source introduction; capitalized passages published in boldface]

[Text] On 20 February 1986, Mir, the new Soviet scientific station, was placed in orbit. V. D. Blagov, deputy flight director and recipient of the USSR's State Prize, tells about the differences between this station and its predecessors, as well as about the unparalleled space flight of L. D. Kizim and V. A. Solovyev.

ITS PREDECESSORS

The Mir orbital station is the new, third generation of the Soviet orbital stations, on which complicated scientific and technical research and experiments have been conducted in space for 16 years now. Everyone knows that even the first-generation stations--from Salyut-1 to Salyut-5--paved the way for man's prolonged stay in space and his productive work in orbit and that they substantially expanded the possibilities for conducting scientific research (for example, in 1976, cosmonauts P. I. Klimuk and V. I. Sevastyanov worked for nine weeks in space aboard the Salyut-4 station). However, the limited reserves of vital supplies--food products, air purifers and engine fuel--and the presence of only one docking terminal did not make it possible to increase the efficiency of space research on board these stations and the stations' active lifespan made it possible for only one or two crews to work on board them (in all not more than 90 days).

The next big step for Soviet cosmonautics was the development [sozdaniye] of the Salyut-Soyuz-Progress orbital scientific research complexes. The second generation Salyut-6 and -7 stations already had two docking terminals.

The development [sozdaniiye] of the Progress freight transport craft solved the problem of supplying the station with all the things the crew needs to live and work. For the first time in space practice they began fueling the station's engine right in space using fuel delivered from the ground on board

the Progress craft. The new scientific equipment which regularly appeared on the station expanded the volume of scientific research and made it possible to adjust their program taking into account the results of the previous stages.

The Salyut-6 station operated in space for nearly 5 years and was occupied by 5 main crews and 11 visiting expeditions, including 8 international ones in which cosmonauts from Czechoslovakia, Poland, the German Democratic Republic, Hungary, Vietnam, Cuba, Mongolia and Romania participated. A record endurance flight of 185 days was completed on it by cosmonauts L. I. Popov and V. V. Ryumin.

The Salyut-7 station is already in its 5th year of operation. The maximum endurance flight for the station's main expedition crews, by L. D. Kizim, V. A. Sevastyanov and O Yu. Atkov, amounted to 237 days (ZEMLYA I VSELENNAYA, 1985, No 2, p 9.--Ed.). The station hosted two international crews with cosmonauts from France and India and the first crew with a woman cosmonaut in it--S. Ye. Savitskaya.

On board the Salyut-7 it was possible to change broken-down equipment and there was a set of special repair tools and the new spacesuits for working in open space made it possible to restore practically any on-board system. And we have managed to extend the station's active lifespan several years (ZEMLYA I VSELENNAYA, 1984, No 3, p 10.--Ed.).

Several of the repair operations done in orbit, by virtue of their complexity and uniqueness, are unprecedented in world space practice. Ones such as, for example, the uncoupling of the antenna for the KRT-10 radiotelescope performed by V. A. Lyakhov and V. V. Ryumin on board Salyut-6; the replacement of the panel for the temperature control system's hydraulic pumps on Salyut-6 performed by L. D. Kizim, O. G. Makarov and G. M. Strekalov; the engine repairs made by L. D. Kizim and V. A. Solovyev on Salyut-7; and finally, the docking with the "silent" Salyut-7 station and the complete restoration of its operational capacity, which were accomplished by V. A. Dzhanibekov and V. P. Savinykh.

Yet all the same there are elements on this station for which the possibilities for repairs are limited. These include the hermetically sealed shell, the viewports and the on-board cable network. And the moment arrives when further use of the station is no longer cost-effective and sometimes it is even dangerous for the crew to work there. In such cases it is necessary to prepare a new station for launching. This is what happened with the Salyut-6 station which was replaced by the Salyut-7 station, which was rather similar to its predecessor (after the end of the last expedition the Salyut-6 flew 8 more months in the automatic mode, yielding valuable information about the operation of the on-board systems beyond the limits of their established lifespans).

And so it was with Salyut-7. After completion of its operational program with the station being manned, the station was placed into a higher orbit (maximum altitude 492 km, minimum altitude 474 km), with a provisional lifespan of more

than 8 years, in order to continue operating in the automatic mode. This makes it possible to receive data that is very important for practical purposes about the operational capacity of the on-board systems beyond the limits of their established lifespans and about the effect of space factors on the structural materials of Salyut-7 and Cosmos-1686. These data will be used during the development [sozdaniye] of future space complexes, orbital scientific platforms, large telescopes and orbital solar power stations, which even in the near future will begin long-term operations in space. Thus, even after completion of its basic program in 1986, the Salyut-7 station will still be serving the people for a long time.

The experience in using the second-generation stations also revealed several of their weak points. The expansion of the volume of scientific research inevitably led to the jamming of the habitation module with equipment delivered by the numerous Progress ships. That meant a worsening of living conditions and indeed, in unusual situations when it is urgently necessary to leave the station, this can create a threat to the crew's safety. Because of the inadequate level of automation of on-board operations the crew was always overloaded with numerous preparatory operations, and, therefore, less time remained for genuinely scientific research.

The peculiarities of the geographic placement of the ground tracking stations led to the fact that communication between the Control Center and the crew could be provided only at specific, fixed intervals and at times it is desirable to have communication at any time necessary.

In addition, two docking terminals were insufficient when the station had long-term operation modules attached to it (as, for example, when the Cosmos-1686 craft was docked at one terminal of the Salyut-7 and the Soyuz-T-15 at the other, this left no place to put the Progress freight craft). The elementary base of many systems, as well as a number of technical solutions, had become obsolete in the time since the laying of the plans for the second-generation stations. We would also add to all this that during the power-consuming scientific research the short supplies of power and fuel for the engine made themselves felt.

In brief, it became obvious that a new generation of station was needed that was highly efficient and free from the enumerated deficiencies.

## THE THIRD-GENERATION STATION

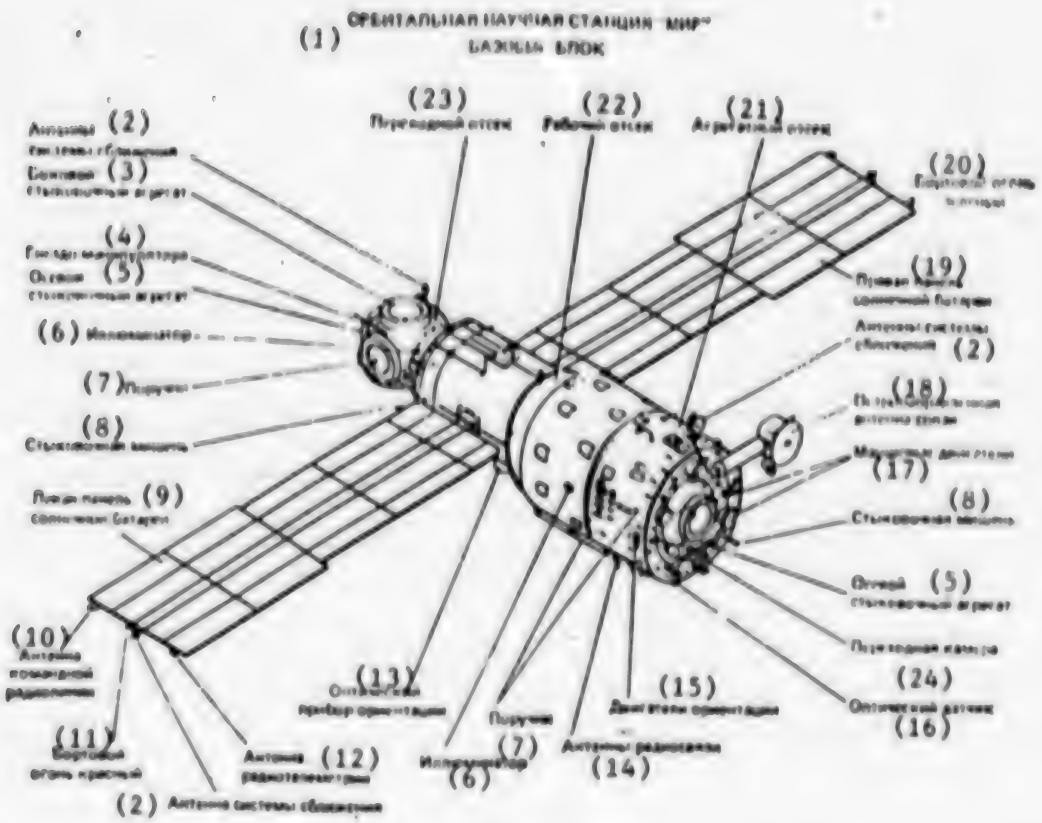
The new station was given the designation Mir, which reflects our people's striving for peace and for the use of space technology only for peaceful purposes. It is easily distinguishable from the Salyut-6 and -7 by its shape. The new adapter module with five docking terminals, the two enlarged-size solar batteries on the small diameter of the habitation module, and the dish of the narrow-beam antenna on the power plant compartment for radio communications via the LUCh [Ray] relay transmitter satellite are the external basic distinguishing signs of this station. In all the Mir has six docking terminals, which makes it possible, in addition to the Soyuz and Progress

crafts, to attach to it another four or five specialized scientific modules with various equipment: telescopes for astrophysical research, cameras and telescopic cameras for studying the earth's natural resources and production plants for making crystals, alloys and biological preparations, all of high quality. The modular principle for the construction of an orbital complex has substantially expanded our capabilities in space research, and specialized modules make it possible to conduct the research in large batches, for a specific purpose and on a regular schedule, and this, of course, will increase the efficiency of the scientific operations.

In order to provide power to the station's operating equipment and scientific equipment, the output of the on-board power plant has been increased twofold. The reliability of the power supply system has been increased and the voltage in the on-board network during load changes has become more stabilized. Inasmuch as the scientific equipment has been moved into the specialized modules, the inside of the station has become roomier and, thus, the crew's work and rest conditions have been improved. There are individual berths, a dining table with individual food warmers and a special place with a tool kit for repairing equipment. The viewports have been freed for visual observations.

The set-up of the station's interior has become much better and the placement of the everyday equipment and the control panels has been done with consideration for ergonomics. There is an audio- and videotape recorder set with an extensive audio and video recordings library. A special radio set has been installed on board the station with a narrow-beam antenna for communications with the Flight Control Center via the stationary Luch relay transmitter satellite. The period of uninterrupted communications has grown from 10-25 minutes to 50-60 minutes each orbit. The capabilities for "dumping" operating and scientific data and for transmitting recommendations to the crew in unusual situations have also been expanded. After the launching of a second relay transmitter communcations will be practically worldwide.

The outdated IGLA [Needle] radio engineering system, which measures parameters of relative motion during docking, has been replaced by the KURS [Course] system, which possesses greater reliability and a greater operating range and, more importantly, does not require that the station be oriented on the approaching craft. The advantage of this system is obvious, if you keep in mind the large mass of the station, especially after specialized modules have been attached to it. In order to control the varied scientific equipment, the operating systems, communications and the attitude, a powerful on-board computer system made up of seven computers has been created. Without the crew's assistance it prepares the scientific equipment for operation, makes the necessary attitude adjustment for the experiment, reminds the crew about the beginning of a communications session and, finally, appeals to the crew for assistance when this is required. The computer contains in its memory all the data about working with the on-board systems and displays the needed information on a screen at the crew's request. This makes it possible to free the crew from auxiliary and routine operations and enables them to concentrate their attention directly on the scientific research. What this means is that




1. Mir orbital scientific station, basic unit.
2. Approach system antenna.
3. Lateral docking unit.
4. Manipulator socket.
5. Axial docking unit.
6. Viewport
7. Handles.
8. Docking target.
9. Solar battery, left panel.
10. Command radio link antenna.
11. Red edge light.
12. Radiotelemetry antenna.
13. Optical attitude-control device.
14. Radio communications antenna.
15. Attitude-control engines.
16. Optical sensor.
17. Sustainer engines.
18. Narrow-beam communications antenna.
19. Solar battery, right panel.
20. Green edge light.
21. Power plant module.
22. Work module.
23. Adapter module.
24. Connecting chamber

now it is possible to send into orbit scientists and specialists in the different fields of space research. The on-board computer is also capable of taking on a number of functions which previously could only be taken care of on the ground. It is capable, for example, of calculating the motion of the station several days in advance and, using these data, of turning on the scientific instruments and the equipment for communications with the ground at any given intervals of time.

While communications sessions are being carried out via the LUCh relay transmitter satellite, the computer makes a prediction with respect to the motion of the station itself and the communications satellite and, with a high degree of accuracy, it aims the on-board antenna at the satellite and ensures automatic tracking of it in the course of the entire communications session.

At the crew's command or upon assignment from the ground, the computer can provide automatic attitude control of any axis of the station to any point in space and either maintain such attitude for several days or change it in accordance with a specified relationship (guidance accuracy--units of angular minutes). After one of the modules has delivered a set of powered gyroscopes, it will be possible to maintain any assigned attitude without any fuel expenditure for all practical purposes. The computer also possesses a lot of capabilities in monitoring the functioning of the on-board systems: it regularly carries out a diagnosis of their operations, independently--in the case of equipment failure--it switches on the back-up unit and informs the crew and the ground about this. The computer programs can be changed or supplemented as need be either by commands from the ground or by replacing the computer memory units with ones delivered to the station.

The Mir station was conceived as a PERMANENTLY ACTIVE orbital station and it is expected to operate for MANY YEARS and is intended to become the base block for the establishment [sozdaniye] of a multi-purpose scientific research complex. And, therefore, during its planning special attention was paid to simplifying repairs to the station's systems. The instruments have been put together in groups and installed in the walls which open up inside the habitation module so that it is more convenient to get to them and to replace them when need be. And although the basic repair method is to change out the instruments, all the same it will sometimes be necessary to repair them. A special work site has been equipped with a set of various tools in the habitation module for such jobs.

The consolidated propulsion system has become more reliable and convenient in its control, as has the temperature control and the gas composition supply systems, the telemetry and television systems and, lastly, the voice communications system. In the modified propulsion system the internal diagnostics systems have been expanded and the accuracy in monitoring the fuel component reserves has increased. Now the station can be refueled to a measured amount with fuel delivered on the Progress ships. The new voice communications system makes it possible for each of the cosmonauts to talk with the ground on different frequencies at the same time, and it is capable of providing communications via both the ground tracking stations and the Luch satellites. In the new system a channel has been provided for non-official converations between the cosmonauts and doctors or family members. In brief, all the Mir station's on-board systems have been designed taking into account not only the present-day requirements, but also those of the near future.

The ground control facilities have been substantially modernized. In the Flight Control Center a new, powerful computer system was installed in the summer for processing and analysis of the more than doubled volume of

telemetry data from on board the Mir station. The branched on-board computer system required powerful computers on the ground as well. Indeed, the volume of digital data transmitted to the station increased by a factor of 2 to 3, and with the specialized scientific modules this volume will increase again by the same amount.

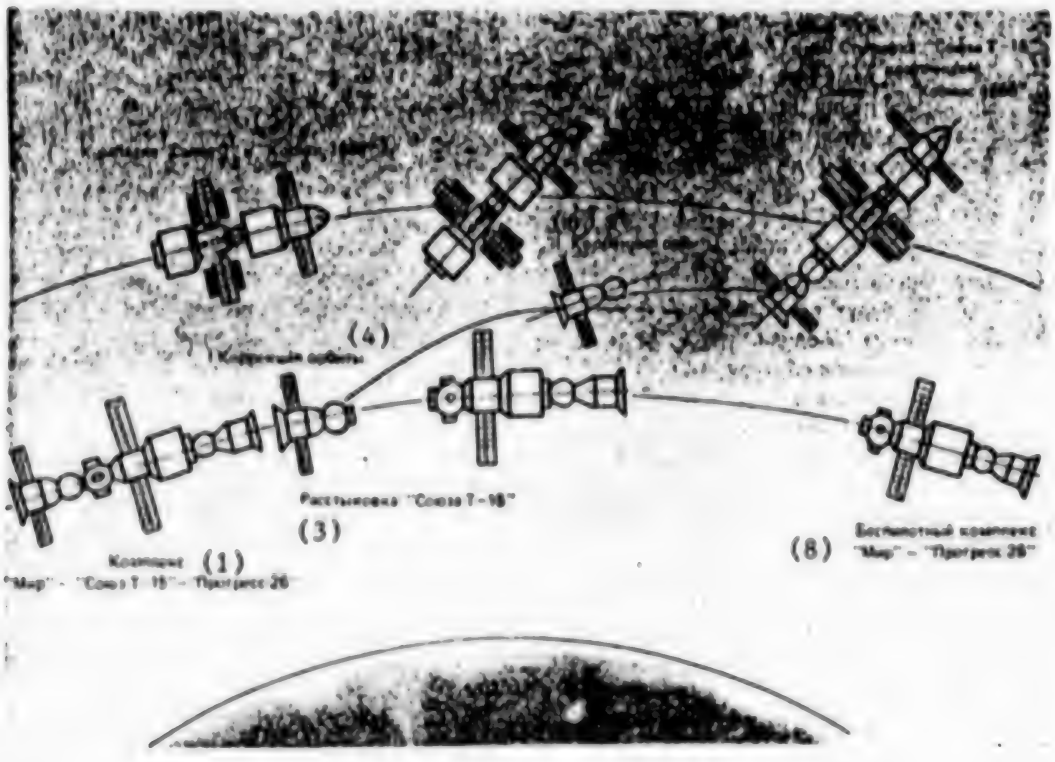
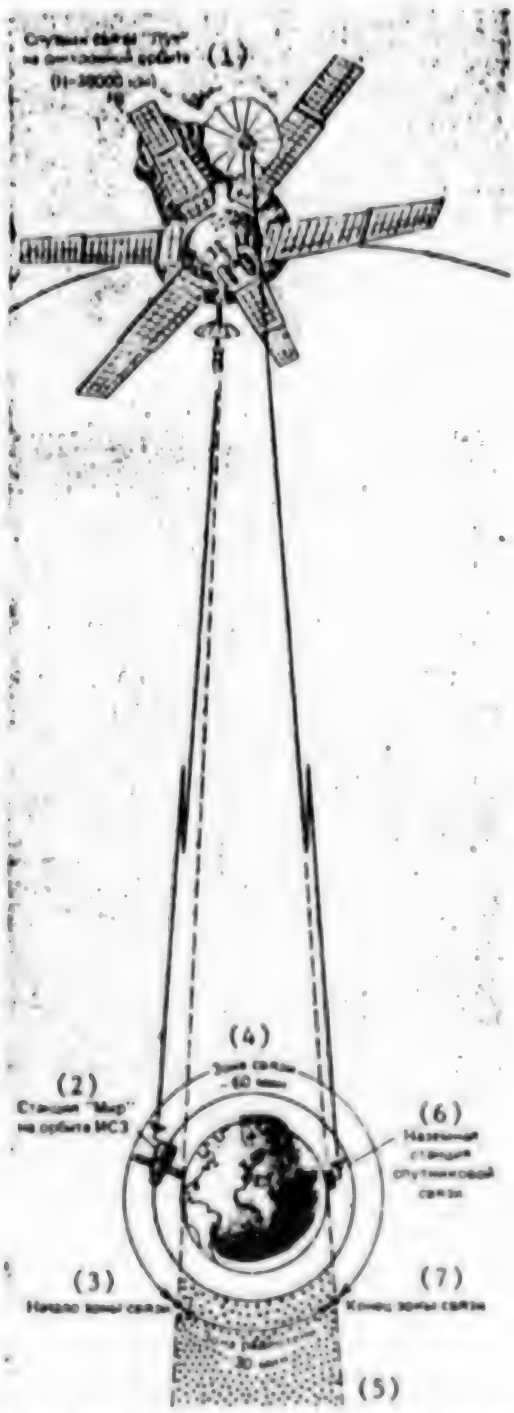



Diagram of the first intraorbital flight of the Soyuz-T-15 from the Mir station to the Salyut-7 station.

1. The Mir-Soyuz-T-15-Progress-26 complex.
2. The Salyut-7-Cosmos-1686 complex.
3. The undocking of the Soyuz-T-15.
4. The first orbit adjustment.
5. Rotation [of Salyut-7-Cosmos-1686 complex].
6. The second orbit adjustment.
7. The docking of the Soyuz-T-15 with the Salyut-7-Cosmos-1686 complex.
8. The unmanned Mir-Progress-26 complex.

INTERORBITAL FLIGHTS

The program of this unique flight presented the Soyuz-T-15 crew and the ground services with complex problems which they solved for the first time in space practice. The crew was faced with having to perform work on the two stations--Mir and Salyut-7--and make two flights from the one station to the




other. The ground services were required to provide simultaneous control for the two orbital complexes and to organize the crew's work on the two stations.

All these problems required careful preparation of the crew, the Flight Control Center and the command and measuring complex. Although Leonid Kizim, Vladimir Solovyev, the Flight Control Center and ground measuring complex specialists were at the time quite familiar with the Salyut-7 station, it was necessary to master the Mir station from the starting point. The difficulty lay in the fact that it was necessary to learn how to work with two stations, which differ in essence in the set-up of their on-board systems and their flight control methods. For example, on board the Mir station, the Soyuz-T and Soyuz-TM craft and the Cosmos-1686 satellite there are computer-based digital control systems, while on the Salyut-7 craft and the Progress freight ships there are only analog control systems, not including the on-board computers.

The Soyuz-T and Progress craft use the IGLA system during approach and the Soyuz-TM uses the new KURS system. And the Mir station has both Igla and Kurs for control of docking with the Progress craft, as well as with the Soyuz-T and Soyuz-TM craft.

**This is how communications are implemented via the Luch relay transmitter satellite.**

1. Luch communications satellite in synchronous orbit.
2. Mir station in satellite orbit.
3. Beginning of communications zone.
4. Communications zone ~60 minutes.
5. Radio shadow zone ~40 minutes.
6. Satellite commo ground station.
7. End of communications zone.

The crew and the ground services, in preparing for this flight, spent several months in training sessions. In them use was made of technological equipment which gives the complete illusion of real working with the Mir station. It has already been stated that on board the Mir station it would first be necessary to master the new system for global communications via the Luch satellite. In order to check the preparedness of all the services and the facilities for providing communications via the Luch relay transmitter satellite, they conducted a unique training session using real objects and ground facilities: they moved the Mir station out of the assembly and testing housing and aimed its antenna at the Luch satellite and checked all the communications modes. The training session was a success.

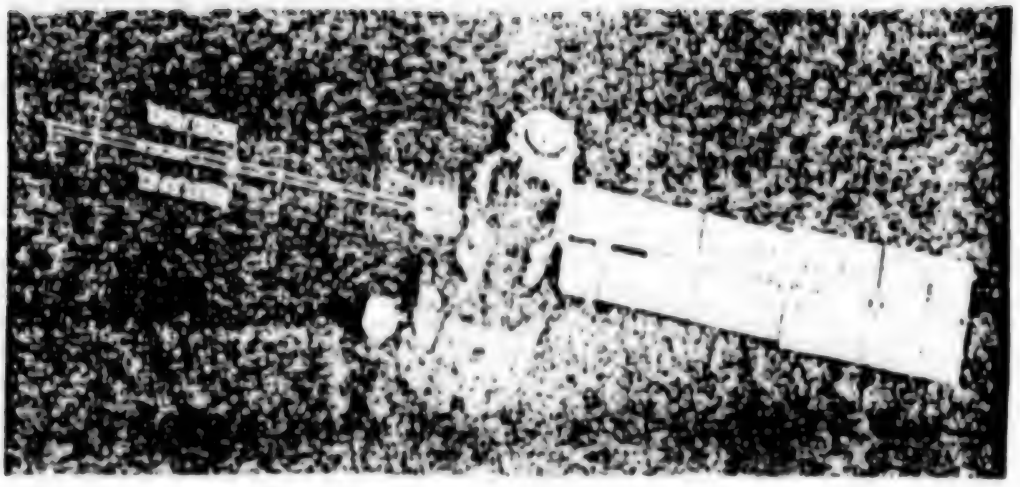
On 20 February, 1986, the Mir station was placed into orbit. In order to carry out the interorbital flights with a minimum expenditure of power it was required that the orbital plane of the new station coincide with the orbital plane of the Salyut-7 station. Therefore they selected an inclination for the future orbit of the Mir station that was equal to the Salyut-7 station's inclination--51.6 degrees, and the launch time was calculated in such a way that at that very moment the Salyut-7 station was over the cosmodrome. It was necessary to endure rather rigid conditions regarding the launch time (the launch window was all of 5 seconds). The placement of the Mir station into orbit went off fine and the Flight Control Center began working with the two stations simultaneously.

On 15 March, the Soyuz-T-15 craft delivered the crew of Mayaki [Beacons]--L. D. Kizim and V. A. Solovyev--to the Mir station. The basic tasks of cosmonauts and the Flight Control Center specialists at this stage were checks of the station's operation in all modes, its computer complex, its attitude control system, the on-board power plant, the communications system via the relay transmitter satellite, and evaluation of the convenience of use of the on-board novelties, as well as installation of the equipment delivered by the Progress-25 and -26 craft and filling up the consolidated propulsion unit with fuel.

There was no scientific research planned for the first stage, inasmuch as the scientific equipment had not been installed yet. After the crew had completely checked the station, preparations were begun for the [intraorbital] flight. The optimum conditions for the flight of the Soyuz-T-15 to the Salyut-7 station would be when the distance between the two stations was 2,000 km and there was good illumination of the Salyut-7 at the time of the Soyuz-T-15's approach to it (the sun at this time would be behind the Soyuz-T-15).

On 5 May, 1986, the Soyuz-T-15 undocked from the Mir station and began the flight, the first interorbital one in the history of cosmonautics, to the Salyut-7 station, which at that time had already completed more than 4 months of flight, together with the Cosmos-1686 satellite, in the automatic mode.

After undocking from the Mir station, the Soyuz-T-15 made two long-range approach maneuvers and the distance to the Salyut-7 was shortened to 12 km. At this moment the Soyuz-T-15's on-board computer automatically aligned the



Mir station in orbital flight. Photo by L. D. Kizim and V. A. Solovyev.

ship with a viewport facing the predicted position of the Salyut-7 station. After coming out of the shadow the crew found the target in the viewport, adjusted the ship's alignment in order to eliminate the prediction error and gave permission for the computer to shift to the autonomous approach mode. The subsequent approach was completely controlled by the computer: maintaining the previous alignment, it periodically switched on the docking engine, bringing the Soyuz-T-15 closer and closer to the Salyut-7 station.

At a distance of 2.2 km, when it was already possible to measure the relative distance to the station with a hand-held laser range finder, the crew took upon themselves the job of controlling the approach. As a result the docking was successfully completed.

L. D. Kizim and V. A. Solovyev delivered to the Salyut-7 station scientific and repair equipment, motion picture and photographic material and magnetic tapes--that is, everything necessary to continue the research started on this station by the previous crew. While performing preventive maintenance on the individual systems of the Salyut-7 and the Cosmos-1686, the crew continued the scientific experiments that were interrupted 4 months back in connection with crew commander V. V. Vasyutin's illness.

The attitude of the complex for carrying out the experiments was achieved with the aid of the Cosmos-1686. This satellite combines the properties of a large transport ship capable of delivering more that three tons of useful supplies, of docking with the station, of boosting its orbit, and of implementing any attitude necessary for carrying out experiments, with the properties of a scientific module as well, carrying specialized research equipment.

EXTRAVEHICULAR ACTIVITY

I would like to tell about one experiment in more detail because it has great significance for the development of cosmonautics of the future. On 28 and 31 May, the crew carried out two extravehicular activity [EVA] sessions in order

to perform the MAYAK EXPERIMENT. During the first EVA L. D. Kizim and V. A. Solovyev set up a special instrument on the station's external surface in order to unfold the truss structure and test its various operating modes--automatic, semiautomatic and manual. On the second EVA they conducted a test of the truss in accordance with the complete program. They moved the truss out to 12 meters, the vibration acceleration pickups installed on it registered the rigidity characteristics of the truss and the high-precision pressure pickups gave a cross-section of the station's own atmosphere. This is the gas cloud exuded by the hull elements, the protective vacuum seals and so on. It normally forms around any space object and causes interference (even if insignificant amounts) in the operation of high-precision optical equipment. The characteristics of the space station's own atmosphere were obta ed for the first time under conditions of actual flight. The data from these sensors went into the telemetry system inside the station by a rather unusual method. Inasmuch as during the EVA it was impossible to set up a large number of high-frequency connectors, an optical system developed [razrabotan] especially for this experiment was placed in the hermetically sealed shell of the station's operations module for the transmission of data using a laser beam passing through the glass of the viewport. Finally, the crew carried out welding of elements of the truss structures outside the station using the URI manual tool electron-beam device (the structure of the unfolding device and the URI device were developed [razrabotat] and made in the USSR Academy of Sciences' Electric Welding Institute imeni Ye. O. Paton).

The results of the tests on the truss structure will be used in the future for the development [razrabotka] of methods and new engineering solutions for the construction of large-size structures in space. Based on the structure developed [otrabotan] on this flight it will be possible to develop [sozdat] simple and compact telescopic devices for moving the cosmonauts and instruments to any point on the external surface of the station to perform inspections and repairs.

## THE SCIENTIFIC AND TECHNICAL COMPLEXES OF THE FUTURE

While the crew was on board the Salyut-7 station, operations with the Mir station did not cease. On 23 May, 1986, the modernized transport ship, the Soyuz-TM, which has replaced the Soyuz-T, performed an automatic docking. The Soyuz-TM's approach and docking was achieved using the previously mentioned new Kurs system and the on-board computer system.

On 30 May, 1986, The Soyuz-TM completed flight tests and landed in the pre-set region. Having carried out the program of scientific research aboard the Salyut-7, the crew shut down the station and the Cosmos-1686 satellite and on 25 and 26 June, 1986, performed a second [intraorbital] flight, but now in the opposite direction--from the Salyut-7 station to the Mir station. At this time a different flight variation was tried: the Igla equipment was used and automatic approach was made up to a distance of 200 meters from the station. From this point on the docking with the station was accomplished manually.

The cosmonauts delivered to the Mir station the materials of the conducted researci, and a lot of the scientific equipment from the Salyut-7 station--spectrometers, motion picture cameras and photo cameras developed [razrabotan] by the specialists of the Soviet Union, the other socialist countries and also France, and the spacesuits in which the cosmonauts had worked in open space. During the second visit to the Mir station the crew installed the delivered scientific equipment in the station's modules and tested them. After the program for the second stay on the Mir station had been completed the crew shut down the station and on 16 July, 1986, returned to the ground.

The successful accomplishment of this complex flight demonstrated the high degree of reliability of Soviet space technology, of the methods for controlling the flight, the unlimited possibilities for their further development [razvitiye] and improvement, and for increasing the efficiency of scientific research.

The launch of the Mir station laid the foundation for the establishment [sozdaniye] in orbit of permanently active, manned scientific research complexes. Scientific research on the earth's natural resources and on unique astrophysical objects, as well as medical and biological will assume permanency. The production of unique alloys and crystals, medicines free from allergens, and various biological preparations will gradually reach an industrial scale. And whole collectives of scientists will begin working in orbit.

The orbital complexes will consist of a large number of modules including ones flying apart from the base block and space tugs will make flights between the modules to service and repair them. But, in order that space serve the people, two main conditions and necessary: cooperation between all the countries of our planet in the exploitation of space and peace, both on earth and in space.



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CSO: 1866/42

## 'PROGRESS-27' LAUNCHED TO 'MIR' STATION

Moscow IZVESTIYA in Russian 17 Jan 87 p 1

[TASS Report]

[Text] In line with the program for ensuring the further functioning of the orbiting scientific station "Mir", an automatic cargo spaceship, "Progress-27", was launched from the Soviet Union on 16 January 1987, at 0906 hours, Moscow time.

The spaceship was launched for the purpose of delivering materials which are subject to depletion and various cargo items to the station.

The "Progress-27" spaceship was placed into an orbit with the parameters: maximum distance from the surface of Earth--280 kilometers; minimum distance from the surface of Earth--189 kilometers; period of revolution--88.9 minutes; inclination--51.6 degrees.

According to telemetry data, the onboard systems of the automatic cargo ship are functioning normally.

FTD/SNAP
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## FCC ACTIVITIES DURING 'PROGRESS-27' LAUNCH

Moscow IZVESTIYA in Russian 17 Jan 87 p 3

[Article by A. Ivakhnov, special correspondent at the Flight Control Center]

[Excerpt] Another stage of work with the orbiting scientific station "Mir" has begun. Launched from the Baykonur Cosmodrome on 16 January was the transport spaceship "Progress-27", which is carrying more than 2 tons of cargo of all kinds to the station.

This year is to be an eventful one in near-Earth orbits. The day is not far off when cosmonauts' voices will be heard again inside the "Mir". A research module with astrophysical instruments will dock with the station somewhat later. This module will become another workplace for the crew. Preparations for the flight of a Soviet-Syrian crew will be completed in the meantime.

We were on the guest balcony of the Flight Control Center. We were joined by USSR pilot-cosmonauts K. Feoktistov and L. Popov, as well as designers and space-technology specialists.

The command "Launch" was given... We then heard "Lift-off!" over the loudspeakers.

Everyone waited for the crucial 530th second, when we heard: "Separation of the ship from the launch vehicle is accomplished. The spaceship 'Progress-27' has gone into the orbit of an artificial Earth satellite." Intense work was only beginning in the so-called "small" room on the second floor of the center. Seated at a console was Vladimir Solovyev, USSR pilot-cosmonaut and twice Hero of the Soviet Union, who was appointed flight director not long ago. Next to him was the head of the shift on duty, who was "steering" the transport ship. Valeriy Ryumin, who preceded Solovyev as flight director, was also there.

FTD/SNAP
/6091
CSO: 1866/64

## 'PROGRESS-27' DOCKS WITH 'MIR' STATION

Moscow IZVESTIYA in Russian 19 Jan 87 p 3

[TASS Report]

[Excerpts] The automatic cargo spaceship "Progress-27" docked with the orbiting station "Mir" on 18 January 1987, at 1027 hours Moscow time.

The mutual search, approach, rendezvousing and docking were carried out with the aid of onboard automatic equipment of the spacecraft. These processes were monitored by the Flight Control Center interacting with the ground command-and-measurement complex.

The cargo spaceship "Progress-27" is docked with the station on the end of its equipment compartment. Fuel for the combined engine unit, and other consumable materials needed to ensure the further functioning of the "Mir" station have been delivered into orbit.

According to telemetry data, the onboard systems of the orbiting complex "Mir"--"Progress-27" are functioning normally.

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## 'SOYUZ TM-2' COSMONAUTS, MISSION DISCUSSED

Moscow TRUD in Russian 29 Jan 87 p 3

[Article by V. Golovachev]

[Excerpt] More than a month ago, we reported that the launching of a Soviet manned spaceship was planned for early in 1987. We also told about the program of the upcoming mission: the cosmonauts would fly to the long-term orbiting station "Mir", and they would prepare to receive a Soviet-Syrian international crew whose launch was tentatively scheduled for 22 July.

We can now report that preparations for the first part of this extensive program have entered the final stage. A space crew arrived recently at the Baykonur Cosmodrome. The commander is USSR pilot-cosmonaut Yuriy Viktorovich Romanenko, a two-time Hero of the Soviet Union, and the flight engineer is Aleksandr Ivanovich Laveykin.

The name of the commander is well-known, while the flight engineer is a newcomer. Both of them have passed a complete course of theoretical and practical studies and also highly difficult training exercises, and they are ready for the mission.

Colonel Yuriy Romanenko, who is 42, has a solid space flight background. He and Georgiy Grechko worked for more than three months on the orbiting station "Salyut-6", where they greeted the new year 1978.

In his second mission, Romanenko was commander of an international crew. Two and a half years after his first mission on "Salyut-6", he returned to it with Cuban citizen Arnaldo Tamayo Mendez. The two of them spent a week working on board the station together with Leonid Popov and Valeriy Ryumin.

Aleksandr Laveykin must have found it very interesting to train for a mission in a crew with such an experienced space pilot as Yuriy Romanenko. He had this to say: "Yuriy is a person who is experienced not only in space flight but in other, everyday matters as well. For me he is both a commander and an older comrade. I find it easy to work with him because of his kindness and good spirits."

Here is how Romanenko characterized his flight engineer: "I liked Sasha right away because of his tactfulness, sense of humor, and willingness to

lend a hand at any moment. We work splendidly together, which was proven by a two-day training session we had in the station, which was placed inside a pressure chamber."

Aleksandr Laveykin took a path that has become traditional for many flight engineers of space missions: high school, the Moscow Higher Technical School imeni Bauman, a design bureau. He began training at Star City in 1984. At the design bureau he worked on problems of the strength of space structures. Naturally, he is anxious to test these structures in conditions of real space flight, which most likely is the dream of every designer of the bureau which was headed by S.P. Korolev. Laveykin has excellent reflexes. He has mastered the science of piloting airplanes.

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## TASS REPORTS LAUNCH OF 'SOYUZ TM-2'

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 7 Feb 87 p 1

[TASS Report]

[Text] In line with the program of space research, the spaceship "Soyuz TM-2" was launched from the Soviet Union on 6 February 1987, at 0038 hours Moscow time, with a crew consisting of Colonel Yuriy Viktorovich Romanenko, the ship's commander, who is a two-time Hero of the Soviet Union and a pilot-cosmonaut of the USSR, and Aleksandr Ivanovich Laveykin, the flight engineer.

The flight program calls for the "Soyuz TM-2" ship to dock with the orbiting complex "Mir"--"Progress-27" and for the crew to carry out planned scientific-technical research and experiments. Also in the course of the flight, testing and perfecting of the improved transport ship of the "Soyuz TM" series will be continued in the manned flight mode.

According to telemetry data, the on-board systems of the "Soyuz TM-2" ship are functioning normally.

Cosmonauts Romanenko and Laveykin are feeling well.

The "Soyuz TM-2" ship is scheduled to dock with the orbiting complex "Mir"--"Progress-27" on 8 February.

(A photograph is given showing the cosmonauts in space suits.)

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/6091
CSO: 1866/64

## BIOSKETCHES OF COSMONAUTS ROMANENKO AND LAVEYKIN

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 7 Feb 87 p 1

[Text] Colonel Yuriy Viktorovich Romanenko, commander of the "Soyuz TM-2" spaceship, is a pilot-cosmonaut of the USSR and a two-time Hero of the Soviet Union. He was born 1 August 1944 in the village of Koltubanovskiy, Buzuluk Rayon, Orenburg Oblast.

After graduating in 1966 from the Chernigov Higher Military Aviation School for Pilots, he served as a pilot-instructor in the Air Force.

Yu.V. Romanenko has been a member of the Communist Party of the Soviet Union since 1965.

Yuriy Viktorovich was enrolled in the cosmonaut contingent in 1970.

Yu.V. Romanenko has made two space flights: the first was in 1977-1978 on the ship "Soyuz-26" and the orbiting station "Salyut-6", and the second was in September 1980 on the ship "Soyuz-38", as commander of a Soviet-Cuban international crew which conducted research and experiments on the "Salyut-6" station.

In 1981, without leaving his principal work, Yuriy Viktorovich graduated from the Air Force Academy imeni Gagarin.

Aleksandr Ivanovich Laveykin, flight engineer of the "Soyuz TM-2" spaceship, was born 21 April 1951 in Moscow.

After graduating in 1974 from the Moscow Higher Technical School imeni Bauman, he worked at a design bureau, where he took part in the development and testing of new models of space technology. He earned a reputation as a technically competent specialist with good initiative.

A.I. Laveykin has been a member of the Communist Party of the Soviet Union since 1980.

Aleksandr Ivanovich was enrolled in the cosmonaut contingent in 1978. He has passed the complete course of training for space flight on the "Soyuz TM" spaceship and the orbiting station "Mir".

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/6091
CSO: 1866/64

## BACKGROUND NOTES ON COSMONAUTS ROMANENKO AND LAVEYKIN

Moscow PRAVDA in Russian 6 Feb 87 p 3

[Article by A. Tarasov, correspondent at the Flight Control Center]

[Abstract] The article is a feature report profiling "Soyuz TM-2" cosmonauts Yuriy Romanenko and Aleksandr Laveykin. Conversations with them were recorded in the final days before the start of their mission, at the Baykonur Cosmodrome. It is noted that their program of prelaunch training here included familiarization with the spaceship, practice on the astrophysical module which is to dock with the "Mir" orbiting station later in the mission, consultations with specialists, going over flight documents, and medical examinations.

The article characterizes the maturity that Romanenko has assumed since his first space mission nearly 10 years ago, together with Georgiy Grechko. An incident from that mission is recalled by Grechko in the article. Grechko was making an exterior inspection of the docking mechanism of the "Salyut-6" station, sticking out from an open hatch while Romanenko held him from inside the station. Romanenko asked to take a look himself outside the hatch. As Grechko moved aside, Romanenko shot up into the hatch opening. Grechko looked and saw that the safety line on Romanenko's suit had not been fastened to anything, and he grabbed it just in time.

Describing Laveykin, the article recalls that after graduating from the Moscow Higher Technical School imeni Bauman, he went to work at the space-technology design bureau. His engineering specialty is structural strength of spacecraft. To help better prepare himself as a cosmonaut, he reportedly learned to fly the L-29 airplane, which, it is noted, is not mandatory for an engineer in the program. His father was General-Major Ivan Pavlovich Laveykin, a military pilot and war hero who died not long ago.

Commenting on the mission, Laveykin said that sufficient time is allowed for them to prepare to receive the astrophysical module. He said that only one of the "Mir" station's complex of computers is currently functioning, and that work on updating the software must be done. Also, dynamic characteristics of the station and its controllability in making turns and orientation stability must be determined.

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/6091
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## COMMENTARY ON FIRST DAY OF 'SOYUZ TM-2' MISSION

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 7 Feb 87 p 1

[Article by G. Lomanov, correspondent at the Flight Control Center]

[Abstract] The article is an on-the-scene report on the launch and early part of the flight of the "Soyuz TM-2" spaceship with cosmonauts Yuriy Romanenko and Aleksandr Laveykin. It is noted that the spaceship's sustainer engine was fired on the fourth orbit to execute the first maneuver, and that an orbit correction also took place on the fifth orbit. The docking with the orbiting station "Mir" was scheduled to take place two full days after the spaceship's launch, instead of the usual one day. It is said that this would help to save fuel for docking maneuvers.

The main work of the crew on board the "Mir" station reportedly will involve continuing the work started by the previous crew in setting up the station's equipment. Numerous systems must be adjusted, and control computers, of which there are several, must be put into operation. The crew will check the dynamic characteristics of the linkage of three spacecraft, which include the "Progress-27" cargo ship that is already docked with "Mir". This will be important for the docking of an astrophysical module, which will arrive during the crew's mission. Then in the summer, the Soviet-Syrian visiting crew will arrive to work on the "Mir" station.

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/6091
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## COSMONAUTS PREPARE FOR DOCKING WITH 'MIR' STATION

Moscow IZVESTIYA in Russian 8 Feb 87 p 1

[TASS Report]

[Text] Flight Control Center, 7 February. As of 1100 hours Moscow time, the spaceship "Soyuz TM-2" piloted by Yuriy Romanenko and Aleksandr Laveykin had completed 23 orbits around Earth.

The crew has carried out routine operations for checking onboard systems of the ship and the seal of its compartments. Manuevers for long-distance rendezvousing with the orbiting complex "Mir"--"Progress-27" have been executed.

Following corrections, the parameters of the "Soyuz TM-2" ship's orbit are: maximum distance from the surface of Earth--308 kilometers; minimum distance from the surface of Earth--269 kilometers; period of revolution--90.1 minutes; inclination--51.6 degrees.

In line with the flight program, tests of the "Soyuz TM-2" transport ship and preparations for docking with the "Mir" station will be continued today.

According to telemetry data and the crew's reports, the flight is proceeding normally. Cosmonauts Romanenko and Laveykin are feeling well.

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## 'SOYUZ TM-2' DOCKS WITH 'MIR' STATION

Moscow IZVESTIYA in Russian 9 Feb 87 p 1

[TASS Report]

[Text] The spaceship "Soyuz TM-2" docked with the orbiting complex "Mir"--"Progress-27" on 8 February 1987, at 0228 hours Moscow time. After checking the seal of the docking mechanism, cosmonauts Yuriy Romanenko and Aleksandr Laveykin went inside the station.

The orbiting scientific station "Mir" has been functioning in near-Earth space since 20 February 1986. The crew of the first expedition, Leonid Kizim and Vladimir Solovyev, conducted comprehensive tests of structural elements, adjusted and tuned instrumentation, and installed additional instruments and equipment on the station.

Plans for the new stage of operation of the "Mir" station call for creating a permanent manned orbiting complex with specialized modules intended for scientific and economic purposes. Comrades Romanenko and Laveykin are to carry out an extensive program of astrophysical, geophysical, technological, technical and medical-biological research and experiments on board the complex.

According to telemetry information, the onboard systems of the manned complex "Mir", which includes the base block and the spaceships "Soyuz TM-2" and "Progress-27", are functioning normally.

The condition of the health of cosmonauts Romanenko and Laveykin is good, and they are feeling well.

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## NEW FEATURES OF 'SOYUZ TM-2' SPACECRAFT

Moscow PRAVDA in Russian 7 Feb 87 p 1

[Article by A. Tarasov, correspondent at the Flight Control Center]

[Abstract] The article reports briefly on the launch and first orbits of the "Soyuz TM-2" spaceship. The author notes that the telemetry indicating the unfolding of the ship's antennas and solar panels was awaited with some anxiety, since the present mission really is a test flight of a ship of a new series. "Soyuz TM-2" is the second ship in the series, and the first to be flown by a crew. It is recalled that the initial "Soyuz TM" ship was launched unmanned last May; it docked with the "Mir" orbiting station and then returned to Earth.

It is said that the main differences of the "Soyuz TM" ships as compared with predecessors lie in "intelligent capabilities," meaning the level of their computer technology and control instrumentation. Konstantin Feoktistov remarked that communications flow mainly between ground control services and onboard computers of the ship. Deputy flight director Viktor Blagov added that the more programmed the ship becomes with software, the more complex flight controllers' work becomes. The number of commands transmitted to the ship is said to have grown greatly.

Asked why the "Soyuz TM-2" would take two days flying to its docking with "Mir" instead of one, Blagov explained that a quick trip requires strong and rough impulses from the engine, consuming a lot of fuel. Also, the fuel of the "Mir" station must be used sparingly, because when it has multiple modules attached to it, it will burn a lot more fuel in making maneuvers. Therefore the "Soyuz TM-2" has a new rendezvousing system called "Kurs" which precludes the necessity of the station maneuvering in order for the ship to dock.

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## COMMENT ON 'SOYUZ TM-2' FLIGHT CONTROL, DOCKING PROCEDURE

Moscow IZVESTIYA in Russian 9 Feb 87 p 2

[Article by Andrey Ivakhnov, special correspondent at the Flight Control Center]

[Abstract] The article reports on activities at the Flight Control Center during the docking of the spaceship "Soyuz TM-2" with the orbiting station "Mir" and the boarding of the station by cosmonauts Yuriy Romanenko and Aleksandr Laveykin.

Doctor of Technical Sciences Vladimir Nikolayevich Pochukayev, director of the center's ballistic service and a USSR State Prize laureate, and USSR pilot-cosmonaut V. Savinykh commented on methods and equipment which were being used to track and correct the flight path of "Soyuz TM-2", and on the procedure for orienting the spaceship and the "Mir" station for docking. Pochukayev mentioned that measurements of the flight paths of the spacecraft were being processed on computers which included one that he described as "semi-intelligent."

Savinykh described the rendezvousing of the spacecraft with the aid of the radar called "Kurs" on "Soyuz TM-2". The radar makes contact with the station at a distance of more than 200 kilometers. Lock-on begins when the ship is 20-30 kilometers from the station.

After Romanenko and Laveykin had gone inside the orbiting station, deputy flight director Viktor Dmitriyevich Blagov commented on the daily schedule of work, which will coincide with Moscow's workday hours.

It is mentioned that Savinykh is a member of one of the Soviet-Syrian crews that are training for a mission on "Mir", to which he may fly in a few weeks if his crew is chosen.

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/6091
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## COMMENT ON 'KURS' GUIDANCE SYSTEM

Moscow PRAVDA in Russian 9 Feb 87 p 1

[Article by A. Tarasov, correspondent at the Flight Control Center]

[Abstract] The article reports on activity at the Flight Control Center during the docking of the "Soyuz TM-2" spaceship with the orbiting station "Mir". In particular, capabilities of the spaceship's new radar system "Kurs" for rendezvousing with the station are described. It is noted that the "Kurs" replaces the system called "Igla" that was used on old "Soyuz" ships. The "Igla" reportedly will continue to be used on automatic cargo spaceships.

Describing the docking, the article notes that the "Kurs" was activated when the spacecraft were 130 kilometers apart. The only maneuver that was required of the "Mir" station was a small correction one-and-a-half orbits before the docking, so that it assumed a position in which it would be clearly visible for the spaceship's television system, with convenient illumination by the sun. The "Soyuz TM-2" reportedly approached the station from the rear end, where the "Progress-27" cargo ship is currently docked. The ship moved smoothly past the station and docked with it at the other end, all automatically.

Quoted in the article are Doctor of Technical Sciences V. Pochukayev, head of the Flight Control Center's ballistics service, and deputy flight director Vladimir Solovyev.

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/6091
CSO: 1866/64

## COSMONAUTS' SECOND DAY ON 'MIR' STATION

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 10 Feb 87 p 1

[TASS Report]

[Text] Flight Control Center, 9 February. Yuriy Romanenko and Aleksandr Laveykin are working for the second day on board the manned complex "Mir".

The cosmonauts are continuing planned operations for putting the station into the manned flight mode. In particular, they have reactivated the life-support and temperature-control systems and checked the functioning of radio and television communications equipment and the condition of other equipment and apparatus.

Beginning 9 February, the crew's workday hours will be from 0800 hours to 2300 hours Moscow time.

According to the cosmonauts' reports and telemetry information, the flight of the manned complex "Mir" is proceeding normally. Its orbit parameters are: maximum distance from the surface of Earth--369 kilometers; minimum distance from the surface of Earth--328 kilometers; period of revolution--91.4 minutes; inclination--51.6 degrees.

Yuriy Romanenko and Aleksandr Laveykin are feeling well.

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## COSMONAUTS UNLOADING 'PROGRESS-27', ORBITAL CORRECTION

Moscow IZVESTIYA in Russian 12 Feb 87 p 1

[TASS Report]

[Text] Flight Control Center, 11 February. The flight of Yuriy Romanenko and Aleksandr Laveykin on board the orbiting complex "Mir" is continuing.

The cosmonauts have completed planned operations for reactivating the base block and have begun unloading the "Progress-27" spaceship. They are carrying foodstuffs in containers, equipment, instruments and scientific apparatus into the station and placing them in their assigned locations.

A correction of the complex's orbit was executed today, using the cargo ship's engine.

According to results of radio conversations with the crew and of medical monitoring data, the process of Yuriy Romanenko's and Aleksandr Laveykin's adaptation to weightlessness is proceeding normally.

The microclimate parameters in the living compartments of the manned orbiting complex "Mir" are: temperature--22 degrees Celsius; atmospheric pressure--830 millimeters of mercury.

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## COSMONAUTS COMPLETE FIRST WEEK ABOARD 'MIR'

Moscow IZVESTIYA in Russian 14 Feb 87 p 1

[TASS Report]

[Text] Flight Control Center, 13 February. Yuriy Romanenko and Aleksandr Laveykin have completed their first week of work in space.

The crew has carried out all planned operations for putting the station into the manned flight mode, and it has inventoried stocks of consumable materials on board the station. A substantial portion of the cargo items delivered by the automatic spaceship "Progress-27" have been transferred inside the base block by the cosmonauts.

Today, the crew will work chiefly on installing new instruments and equipment and checking their functioning, in line with the plan for further equipping of the station. The day's agenda calls also for physical exercise.

After a strenuous week of work, tomorrow will be a day of rest for Yuriy Romanenko and Aleksandr Laveykin.

Both cosmonauts are feeling well.

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## COSMONAUTS REFUEL 'MIR', PERFORM MEDICAL EXAM

Vilnius SOVETSKAYA LITVA in Russian 19 Feb 87 p 1

[TASS Report]

[Text] Flight Control Center, 17 February. Cosmonauts Yuriy Romanenko and Aleksandr Laveykin are continuing their work on board the manned complex "Mir". Today they are installing medical apparatus which was delivered to the complex by the "Progress-27" ship, and they are checking its operation. As the automatic transport ship is unloaded, the cosmonauts are filling it with depleted equipment.

After checking the seal of fuel lines and pumping compressed nitrogen out of tanks, the refueling of the station's combined engine unit was carried out.

The crew performed their first comprehensive medical examination yesterday. It included examination of the cosmonauts' cardiovascular systems, measurement of body weight, and evaluation of the condition of muscles which are not exerted much in zero gravity.

The results of the examination showed that the health of Comrades Romanenko and Laveykin is good.

The flight of the orbiting complex "Mir" is proceeding normally.

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/6091
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## COSMONAUTS COMPLETE WORK WITH 'PROGRESS-27', BEGIN VISUAL OBSERVATIONS

Moscow IZVESTIYA in Russian 21 Feb 87 p 1

[TASS Report]

[Text] Flight Control Center, 20 February. The third week of Yuriy Romanenko's and Aleksandr Laveykin's orbital flight has begun.

The cosmonauts are completing work with the automatic transport ship "Progress-27". They have moved delivered cargo items into the base block, and they are filling the emptied compartment of the transport ship with depleted equipment. The "Mir" station's combined engine unit has been completely refilled with fuel and an oxidizing agent.

The crew is beginning geophysical studies today; two series of visual observations of individual areas of the Earth's surface are planned. Plans call also for cleaning the station's living compartments and for physical exercise. Time has been set aside for rest and a television report. One more correction of the manned complex's orbit will be executed in the evening, using the engine of the cargo ship "Progress-27".

The "Mir" station has been functioning in near-Earth space for one year. According to the crew's reports and results of telemetry information, all of the station's systems are operating normally.

Cosmonauts Yuriy Romanenko and Aleksandr Laveykin are healthy and are feeling well.

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/6091
CSO: 1866/64

## 'PROGRESS-27' UNDOCKS FROM 'MIR' STATION

Moscow IZVESTIYA in Russian 24 Feb 87 p 2

[TASS Report]

[Text] Flight Control Center, 23 February. Following completion of the program of joint flight, the automatic transport spaceship "Progress-27" was separated from the orbiting complex "Mir" today at 1429 hours Moscow time. The process of the ship's undocking and withdrawal was monitored by specialists of the Control Center and by cosmonauts Romanenko and Laveykin.

All planned operations, which included unloading of the ship and refueling of the station and transferring of drinking water into it, were carried out in their entirety during the time of the joint flight. Two corrections of the complex's orbit were executed with the aid of the engine of the cargo ship "Progress-27".

Today, Yuriy Romanenko and Aleksandr Laveykin are working on technical maintenance of the station and preparing apparatus for upcoming research. The flight is proceeding normally. Both cosmonauts are healthy and are feeling well.

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/6091
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## TASS REPORTS DESTRUCTIVE REENTRY OF 'PROGRESS-27'

Moscow IZVESTIYA in Russian 27 Feb 87 p 2

[TASS Report]

[Text] Flight Control Center, 25 February. The flight of the automatic transport ship "Progress-27", which went into near-Earth orbit on 16 January 1987, has ended.

Today on commands from the Control Center the cargo ship was oriented in space, and then its engine was fired at 1817 hours Moscow time. As a result of braking, the "Progress-27" ship went into a descending trajectory, entered the dense layers of the atmosphere, and ceased to exist.

Yuriy Romanenko and Aleksandr Laveykin are continuing their mission on board the manned complex "Mir". In the past days the cosmonauts have been working mainly on checking scientific apparatus and preparing it for operation. Tomorrow they will perform a series of geophysical studies, which will include photographing of individual regions of the Earth's surface, and they will begin technical and technological experiments.

The condition of the health of both cosmonauts is good, and they are feeling well. The flight of the orbiting complex "Mir" is proceeding normally.

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/6091
CSO: 1866/64

## COSMONAUTS BEGIN FOURTH WEEK IN ORBIT

Moscow IZVESTIYA in Russian 28 Feb 87 p 3

[TASS Report]

[Text] Flight Control Center, 27 February. The fourth week of Yuriy Romanenko's and Aleksandr Laveykin's flight in orbit has begun. During the days just past, the cosmonauts performed a number of experiments and worked on the further equipping of the base block.

In line with the program for study of Earth natural resources and the environment, individual areas of land surface and the waters of the world's oceans were photographed, using stationary cameras.

Space materials-science experiments with the unit "Pion-M" have begun. The purpose of these experiments is to study processes of heat and mass transfer in liquid media, in conditions of microgravitation.

According to the cosmonauts' reports and telemetry information, the onboard systems of the manned orbiting complex "Mir" are functioning normally.

The condition of Yuriy Romanenko's and Aleksandr Laveykin's health is good, and they are feeling well.

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/6091
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## COSMONAUTS PERFORM 'KOLOSOK' EXPERIMENT TO STUDY AEROSOLS

Moscow SOVETSKAYA ROSSIYA in Russian 4 Mar 87 p 1

[TASS Report]

[Text] Flight Control Center, 3 March. Cosmonauts Yuriy Romanenko and Aleksandr Laveykin are continuing planned work on board the orbiting complex "Mir".

The flight program during the days just past included technical, technological and geophysical experiments, as well as routine preventive-maintenance operations on the station.

Today's agenda calls for another medical examination of the crew. The functional condition of the cosmonauts' cardiovascular systems will be evaluated, and a number of medical-biological studies will be made.

Experiments in line with the space materials-science program are continuing. An experiment called "Kolosok" is being performed for the purpose of studying the dynamics of structure formation of aerosols in conditions of zero gravity.

In line with assignments from specialists of various branches of the country's economy, the cosmonauts will perform several more series of visual observations and photographing of individual areas of the Earth's surface.

The flight of the manned complex "Mir" is proceeding normally.

The condition of Yuriy Romanenko's and Aleksandr Laveykin's health is good, and they are feeling well.

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/6091
CSO: 1866/64

## TASS REPORTS LAUNCH OF 'PROGRESS-28'

Moscow IZVESTIYA in Russian 5 Mar 87 p 1

[TASS Report]

[Text] In line with the program for ensuring the further functioning of the orbiting scientific station "Mir", the automatic cargo spaceship "Progress-28" was launched from the Soviet Union on 3 March 1987 at 1414 hours Moscow time.

The purpose of the launching of the ship is to deliver consumable materials and various cargo items to the station.

The "Progress-28" ship was placed into an orbit with the parameters: maximum distance from Earth's surface--272 kilometers; minimum distance from Earth's surface--191 kilometers; period of revolution--88.8 minutes; inclination--51.6 degrees.

According to telemetry information, the onboard systems of the automatic cargo ship are functioning normally.

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/6091
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## 'PROGRESS-28' DOCKS WITH 'MIR' STATION

Moscow SOVETSKAYA ROSSIYA in Russian 6 Mar 87 p 1

[TASS Report]

[Text] The spaceship "Progress-28" docked with the manned orbiting complex "Mir"--"Soyuz TM-2" on 5 March 1987, at 1543 hours Moscow time.

The mutual search, approach, rendezvousing and docking were carried out with the aid of onboard automatic equipment of the spacecraft. These processes were monitored by the Flight Control Center interacting with the ground command-and-measurement complex, and also by cosmonauts Romanenko and Laveykin. The cargo ship docked with the station on the side where its equipment compartment is located.

The "Progress-28" ship delivered into orbit fuel for the combined engine unit, foodstuffs, water, equipment and apparatus for the further equipping of the "Mir" station, and mail.

According to telemetry data and the crew's reports, the onboard systems of the manned complex "Mir"--"Soyuz TM-2" are functioning normally.

The condition of Yuriy Romanenko's and Aleksandr Laveykin's health is good, and they are feeling well.

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/6091
CSO: 1866/64

## COSMONAUTS COMPLETE FIRST MONTH IN ORBIT

Moscow SOVETSKAYA ROSSIYA in Russian 7 Mar 87 p 1

[TASS Report]

[Text] Flight Control Center, 6 March. The space mission of Yuriy Romanenko and Aleksandr Laveykin has been in progress for a month. All planned work on the further equipping of the base block and work in line with the mission's scientific program have been carried out in entirety by the crew.

Work with the "Progress-28" spaceship is scheduled for today, as are experiments for studying features of the behavior of hydrosols and aerosols in conditions of zero gravity, and visual observations and photographing of individual areas of land surface and the waters of the world's oceans, using hand-held cameras.

During the days just past, a series of experiments called "Vikhr" was performed with the unit "Pion-M", in line with the space materials-science program. The purpose of these experiments is to study convection currents produced in a liquid by forces of surface tension in the presence of a temperature gradient.

According to telemetry information and reports from orbit, the flight of the manned complex "Mir" is proceeding normally.

Cosmonauts Yuriy Romanenko and Aleksandr Laveykin are healthy and are feeling well.

FTD/SNAP
/6091
CSO: 1866/64

## COMMENTS ON MATERIALS STUDIES ON 'MIR' STATION

Moscow KOMSOMOLSKAYA PRAVDA in Russian 7 Mar 87 p 2

[Article by S. Leskov]

[Excerpt] Cosmonauts Yuriy Romanenko and Aleksandr Laveykin have been working for one month on board the orbiting station "Mir". A major event for the crew occurred two days ago. The cargo spaceship "Progress-28" docked with the complex "Mir"--"Soyuz TM-2".

Romanenko and Laveykin are conducting studies with the unit "Pion-M", which has already proved itself on the "Salyut-7" station. The goals of these studies are far-reaching ones--laying the scientific groundwork for industry in space. But first problems of the physics of surface phenomena and of hydrodynamics and heat exchange in zero gravity must be clarified, as well as new laws of phase transitions, and methods must be learned for utilizing such factors as vacuum and the absence of gravity for the purpose of obtaining superpure semiconductors, alloys, and medicinal preparations.

In the opinion of Professor L.V. Leskov, one of the directors of the experiments with the "Pion" unit, the cosmonauts have obtained results that are interesting for understanding thermocapillary convection, a phenomenon that is insignificant on Earth but of major importance for processes in space.

Colloid chemistry experiments for studying electrostatic fields of force around aerosols and hydrosols were organized with the participation of the USSR Academy of Sciences' Institute of Physical Chemistry. These experiments are relatively simple as yet. All that is necessary is to shake a test tube and see what happens in it, and how particles cling together.

But very curious things have come of this. The cosmonauts have documented how particles of silica aerogel in suspension in a test tube conglomerate, forming tiny saucers about 5 millimeters in size which are suspended with no support. Scientists must now figure out what is happening here.

This series of experiments is called "Kolosok". Scientists plan soon to eliminate the primitive method of shaking test tubes from "Kolosok". Precisely calculated ultrasonic pulses will produce measured effects at certain

frequencies and intensities and in certain directions. It will become possible to create the "saucers" and other objects to order.

Among the many things the "Progress-28" ship brought from Baykonur to "Mir" is an electric furnace called "Korund" for producing semiconductors, metals and alloys. It, too, is no newcomer on orbiting stations. The Korund, incidentally, has the largest capacity in the family of space furnaces.

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MANNED MISSION HIGHLIGHTS

## EXPERIMENTS WITH 'PION-M' UNIT

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 7 Mar 87 p 1

[Article by G. Lomanov, correspondent at the Flight Control Center]

[Excerpt] The cargo spaceship "Progress-28" docked with the orbiting complex "Mir"--"Soyuz TM-2" on Thursday.

"'Progress-28' has delivered food, equipment and fuel for the station--more than 2 tons in all," related deputy flight director V. Blagov right after the docking. "As you know, the 'Mir' station can receive several scientific modules. Until the first of them arrives, the station will have scientific instrumentation added from the inside rather than the outside. Last year cosmonauts Kizim and Solovyev brought cameras and hand-held spectrometers over from the 'Salyut-7' station. And now we have sent up to the cosmonauts the high-precision camera 'KATE-140' for geodetic surveys, which has already been used in orbit, and a technological unit, 'Korund', for growing crystals. Cosmonauts Romanenko and Laveykin will move this unit into the station first of all--we plan to start working with it on Monday."

One of the first stages of the scientific program has been a series of experiments with the unit called "PION-M". The letters PION make up an acronym standing for [the Russian]: instrument for the study of features of zero gravity.

"From school everybody knows that in zero gravity there is no convection, that only on Earth do heated liquids and gases mix," related Doctor of Physical-Mathematical Sciences Leonid Vasilyevich Leskov. "The very first experiments in space materials science, however, forced some 'provisos' to be made in this textbook fact. There is convection, but it manifests itself differently. This so-called thermocapillary convection is actively involved in processes of melting and crystallization; it detracts from the properties of materials obtained in the 'Splav' and 'Kristall' units. Space 'furnaces' of this type have operated on orbiting stations for a long time, but since they were closed, the dynamics of phenomena occurring in them could not be observed. The 'PION' unit has a transparent tray that contains a model liquid through which a beam of light can pass. Non-uniformities distort the light beam, and it can be recorded on film how the density of the medium changes in the course of an experiment.

"It is possible to sprinkle some special 'markers'--particles of a powder--into the liquid. In bright light they sparkle like sequins. Many of your readers probably have seen pictures taken with the aid of a pulsing strobe light. This method is used in the 'PION'. From the traces of a 'marker' one can follow its path and judge its rate of movement."

Experiments with the first "PION" research unit began back in 1981. Since then a substantial amount of material for analysis has been accumulated. But space always holds new surprises and presents scientists with new riddles to figure out.

Associates of the USSR Academy of Sciences' Institute of Physical Chemistry came up with a series of experiments in colloid chemistry. Microscopic particles of various materials were placed inside ampoules. Results have surprised even the scientists. Silica aerogel, a variety of glass, conglomerated into rather large masses shaped like saucers. Fluoroplastics formed weird tree shapes, and glass pellets gathered into solid clumps. And even bits of stainless steel which were placed specially in each ampoule as "mixers" could not break them up. It appears that the scientists have entered into a new and puzzling field of colloid chemistry.

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## COSMONAUTS UNLOADING 'PROGRESS-28', BOOST STATION ORBIT

Moscow IZVESTIYA in Russian 11 Mar 87 p 1

[TASS Report]

[Text] Flight Control Center, 10 March. Cosmonauts Yuriy Romanenko and Aleksandr Laveykin are continuing their work on board the manned complex "Mir".

In line with the mission program, the crew is unloading the automatic transport ship "Progress-28" and is continuing to place new equipment in the station. Yesterday the cosmonauts installed additional automation units in the electric system, and today they will complete the installation and test the functioning of the technological unit "Korund", which is intended for space materials science experiments.

On 9 March, with the aid of the cargo ship's engine, a correction of the orbit of the "Mir" complex was executed. At the present time its parameters are: maximum distance from the surface of Earth--386 kilometers; minimum distance from the surface of Earth--355 kilometers; period of revolution--91.7 minutes; inclination--51.6 degrees.

According to reports from orbit and telemetry data, the flight is proceeding normally.

Yuriy Romanenko and Aleksandr Laveykin are healthy and are feeling well.

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MANNED MISSION HIGHLIGHTS

## IMPROVED 'KORUND' UNIT INSTALLED ON 'MIR' STATION

Moscow IZVESTIYA in Russian 14 Mar 87 p 1

[TASS Report]

[Text] Flight Control Center, 13 March. Yuriy Romanenko and Aleksandr Laveykin have completed their fifth week of orbital flight.

The crew's program of work in the days just past included space technology experiments, installation of the stationary camera "KATE-140", pumping of water from tanks of the cargo ship into containers on the station, and visual observations of the Earth's surface.

Preparations have been completed for operating the modernized technological apparatus "Korund", which is intended for producing semiconductor materials with improved characteristics in conditions of microgravitation. The "Korund" apparatus has an electric furnace which is designed to work with six specimens in sequence, and a microcomputer-based control system which allows experiments to be conducted automatically, according to a program that is set beforehand.

Today is another medical day for the crew of the orbiting complex. Scheduled is an examination of the cosmonauts' cardiovascular systems in conditions of rest and of a measured amount of physical exertion on the stationary bicycle. Recording of physiological parameters will be done using the multifunctional apparatus "Gamma" and an ultrasonic cardiograph.

According to telemetry data and the crew's reports, the flight of the manned complex "Mir" is proceeding normally. Cosmonauts Yuriy Romanenko and Aleksandr Laveykin are feeling well.

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## COMMENTARY ON NEW 'KORUND' UNIT

Moscow PRAVDA in Russian 17 Mar 87 p 6

[Article by A. Pokrovskiy, correspondent at the Flight Control Center]

[Abstract] The article reports briefly on the "Korund" technological unit on the orbiting station "Mir". It is the latest in a series of furnaces of the same type, which have been used for perfecting processes of making semiconductor materials on board orbiting stations. "Korund" is said to differ from its predecessors such as the "Kristall", "Splav" and "Magma-F" units in that it is larger, weighing 136 kilograms, and possesses greater capabilities. It is referred to as a pilot-scale unit, whereas the others were research units.

It is recalled that the first version of the "Korund" was operated by Anatoliy Berezovoy and Valentin Lebedev on the "Salyut-7" station. According to Candidate of Technical Sciences Ye. Markov, single crystals of cadmium selenide and indium antimonide which they grew there and brought to Earth were found to possess properties very close to desired ones. Therefore it was decided to continue crystal-growing experiments with a somewhat modernized "Korund" unit. Markov explained that the modernizing was aimed at giving the unit more of an industrial character, so that basic production processes could be perfected on it. Six processes for 10 different materials are planned for testing, according to Markov.

The new "Korund" reportedly has a built-in minicomputer so that experiments can be conducted automatically. It is said that both the profile of the heating zone and the rate of movement of ampoules with specimens can be varied. The temperature can be varied from 20 to 1,270 degrees, and it can be held steady within one-half of a degree. Experiments can last from 6 to 150 hours. The output of the "Korund" is said to be measured in kilograms of semiconductor materials. All that the operator reportedly had to do is to load ampoules with specimens into a special drum. The drum turns according to a control program, holding the ampoules in the heating zone in the prescribed sequence.

It is mentioned that the materials produced in the "Korund" are to be used in electronics and in infrared and laser equipment.

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## COSMONAUTS PERFORM GEOPHYSICAL STUDIES, MATERIALS EXPERIMENT

Moscow SOVETSKAYA ROSSIYA in Russian 18 Mar 87 p 2

[TASS Report]

[Text] Flight Control Center, 17 March. Yuriy Romanenko's and Aleksandr Laveykin's mission is continuing on board the manned complex "Mir".

A large portion of the crew's working time today is devoted to geophysical studies. The cosmonauts will perform several series of picture-taking of the territory of the Soviet Union, in particular, Kazakhstan, southern Siberia and the Far East, using photographic and spectrometric apparatus.

A space materials-science experiment in the "Korund" unit, which began on 13 March, is nearing completion. The purpose of this experiment is to obtain single crystals of a semiconductor material in conditions of zero gravity and to determine optimal conditions for a production process.

While carrying out the mission's scientific program, the cosmonauts at the same time are continuing to install additional equipment on board the orbiting complex's base block. This equipment was delivered by the cargo spaceship "Progress-28".

According to reports from orbit and telemetry data, the flight of the manned complex "Mir" is proceeding normally. The condition of Yuriy Romanenko's and Aleksandr Laveykin's health is good, and they are feeling well.

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## COSMONAUTS ROMANENKO, LAVEYKIN COMPLETE SIXTH WEEK IN ORBIT

Moscow TRUD in Russian 21 Mar 87 p 1

[TASS Report]

[Text] Flight Control Center, 20 March. Yuriy Romanenko and Aleksandr Laveykin have been working in near-Earth orbit for six weeks.

During the days just past, the crew of the manned complex "Mir" performed a number of medical experiments and photographed the Earth's surface.

The cosmonauts have completed the unloading of the transport spaceship "Progress-28". All of the cargo that was delivered into orbit has been moved into the station's rooms, and drinking water has been transferred.

A large portion of the crew's working time today is reserved for geophysical experiments, which are being conducted within the framework of an extensive program for study of Earth natural resources and the environment. With the aid of stationary cameras and spectrometers, the crew has performed several series of picture-taking of our country, including territory of the Central Asian republics, the Caspian lowland, and the Caucasus.

According to the crew's reports and telemetry data, the flight is proceeding normally. Yuriy Romanenko and Aleksandr Laveykin are healthy and feeling well.

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## BULGARIAN COSMONAUTS BEGIN TRAINING IN USSR

Moscow KOMSOMOLSKAYA PRAVDA in Russian 11 Jan 87 p 1

[Text] On 10 January, Aleksandr Aleksandrov and Krasimir Stoyanov of Bulgaria arrived in Moscow to prepare for the second Soviet-Bulgarian space mission. In a few days, they will begin studies and training at the Cosmonaut Training Center imeni Gagarin.

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## BACKGROUNDS OF BULGARIAN COSMONAUTS

Moscow KRASNAYA ZVEZDA in Russian 11 Jan 87 p 3

[Article by V. Khrustov, correspondent]

[Text] Aleksandr Aleksandrov and Krasimir Stoyanov of Bulgaria arrived in Moscow on 10 January to prepare for the second Soviet-Bulgarian space mission. In a few days they will begin studies and training at the Cosmonaut Training Center imeni Gagarin.

Aleksandr Aleksandrov is not a newcomer to cosmonautics. Journalists know him from before at Star City and the Flight Control Center, when he was the backup for the first Bulgarian cosmonaut, Georgiy Ivanov, who worked in space in 1979 with Nikolay Rukavishnikov.

In the seven years since that mission, Aleksandrov not only has kept in top physical shape, as they say, but he also has taken a step forward professionally--he defended a dissertation. Now Candidate of Technical Sciences A. Aleksandrov is deputy director of the Bulgarian Academy of Sciences' Institute of Space Research.

As Krasimir Stoyanov stands ready to master his new specialty, he has a solid background for this: at age 27, Air Force Lieutenant Stoyanov already is an experienced pilot.

S. Bogodyazh, head of the department of international relations of the USSR Main Administration for the Development and Use of Space Technology for the Economy and Scientific Research (Glavkosmos), related that in a few days the Bulgarian cosmonauts will begin studies and training at the Cosmonaut Training Center imeni Gagarin. The start of the Soviet-Bulgarian expedition is scheduled for 1988. Bogodyazh noted that for the first time at Star City, three international crews are in training at the same time.

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SPACE SCIENCES

## X-RAY ASTRONOMY INSTRUMENTS TO OPERATE ON 'MIR' STATION

Moscow APN: ADVANCES OF SCIENCE AND TECHNOLOGY in English No 21, 5 Nov 86 pp 1-3

[Article by Tamara Breus, Candidate of Physical-Mathematical Sciences]

[Text] Soviet scientists plan to launch several space observatories into near-Earth orbit. The rest of the world will have nothing of that scope and potential till at least the mid-1990s. Few land-based facilities will equal them in the efficiency of telescopes and information processing systems. One of the Soviet orbital projects involves the Netherlands, West Germany and the European Space Agency. The laboratory will cary four X-ray telescopes with individual operating bands. This observatory will be part of the Mir orbital complex. Preparations for its launching have reached their final stage.

Observations in the X-ray band are needed to diagnose hot space plasma available at practically all astrophysical objects, from nearby stars of the Sun's type to the remotest quasars and clusters of galaxies. This information can explain the nature and dynamics of explosions and the properties of matter under extreme physical conditions which cannot be simulated on Earth.

Characteristic of the initial stage of extraterrestrial astronomy were light portable telescopes which could be delivered into space by the then existing launchers. Actually, these telescopes had little in common with telescopes as we know them, but rather resembled instruments used in nuclear physics. They were installed aboard satellites along with other instrumentation.

The Soviet Salyut orbital stations were the first to carry new types of telescopes into space. The Salyut-7 station, for instance, carried a pilot specimen of an X-ray telescope-cum-spectrometer, a modernised version of which was later installed aboard the Astron orbital observatory.

The Mir station offers still greater opportunities for astronomical observations by ensuring high guidance accuracy in the automatic regime. Even more important, it extends the period of observations without impairing other research programmes.

The station's observatory will use X-ray telescopes operating within a wide band of energies. They will make it possible to solve new in principle astrophysical tasks unattainable for the available space-based telescopes.

The new observatory is unprecedented in terms of the operational energy band, spectral resolution and other physical and technical characteristics. It will outdo the West European Spacelab. Equipment and instruments for the Mir X-ray observatory were developed and manufactured through the collective efforts of the Soviet Union, the Netherlands, West Germany and the European Space Agency.

The Soviet Pulsar X-1 telescope's hard X-ray radiation detectors have an effective area six times larger than that of a similar American instrument on the HEAO-satellite. The detector block was tested aboard the Salyut-7 station during the Siren experiment. The tests confirmed that the instrument characteristics conform to the design variable.

The telescope includes a special wide-angled detector of X-ray and gamma-radiation bursts. Thanks to the size of the detector, which is much bigger than any standard-size version, scientists will get detailed spectrums of bursts and will be able to monitor their evolution.

Dutch scientists designed a special telescope to operate in the medium-energy region of the spectrum, which is out of bounds for conventional optical systems. Being the first experiment of its kind, it is expected to yield exceptionally important information.

Although Dutch scientists have been known as veterans of space exploration, this is their first experience in cooperating with Soviet space researchers.

The telescope designed by the Dutch specialists incorporates a new principal of obtaining images with a resolution of several angular minutes. The input port of the telescope is provided with a shadow coding mask with several square perforations arranged in a strictly specified manner. The aggregate area of the perforation amounts to about 50 percent of the area of the telescope's input port. Upon reaching the telescope a parallel beam of photons, emitted by a remote source, forms a shadow image of the coding mask in the plane of the X-ray radiation detector. A mathematical analysis of the photon registration points will give an idea of the distribution of X-ray radiation brightness throughout the celestial sphere.

The second X-ray telescope, developed by the Dutch scientists, is based on a different principle of X-ray quanta measurement. It registers gas scintillations -- ultraviolet radiation bursts of a preset duration corresponding to the energy of quanta. As a result, the telescope has a resolution two times greater than conventional meters.

A West German telescope was designed at the Max Planck Institute, West Germany's leader in high energy astrophysics.

For the Space Telescope Soviet scientists designed special instruments to control the entire complex and the distribution of telemetry information channels, and provided the power supply system.

According to West European scientists the Mir station gives them far greater opportunities than their national programs could offer.

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# OPTIMAL TWO-BOOST FLIGHTS TO ASYMPTOTIC TRAJECTORY

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA: FIZIKA, ASTRONOMIYA in Russian
Vol 27, No 5, Sep-Oct 86 (manuscript received 13 Jun 85) pp 40-43

[Article by S.I. Sumarokov, GAISh [State Astronomy Institute imeni P.K. Shternberg]]

[Abstract] An estimate is made of the energy input required to place a spacecraft on an asymptotic path which includes libration point $L_2$ of the earth-moon system. The procedure for calculating optimal boost trajectories used by D'Amario, Pu and Edelbaum (1974, 1975) is used, based on the combined utilization of the method of many conic sections and Lowden's basis vector theory (1966). The following approximations are used: The earth and moon are regarded as material points; the moon moves around the earth in a circle; all the trajectories studied lie in the plane of the moon's circular orbit around the earth; and the mass of the spacecraft is negligibly low. The spacecraft's motion is studied in a right-handed rotating coordinate system, OXY, with its origin at the earth-moon barycenter, whereby axis OX is directed toward the moon along the earth-moon straight line and axis OY completes the coordinate system to the right. The units of measurement are chosen so that the sum of the masses of the earth and moon equals a unit and the angular velocity of the line connecting the earth and moon also equals a unit. The unit of distance used is the average distance between the earth and moon, so that the unit of time equals 104.361 h and the unit of velocity 1023.18 m/s. The altitude of the circular near-earth orbit is assumed to be 185.2 km. Two-boost flights from the orbit to a certain fixed point, F, on the asymptotic trajectory are examined. One boost is applied at point I on the circular orbit, and another at point F. Thereafter the spacecraft moves under the influence only of the gravitational forces of the earth and moon. The relationship between energy input and flight time is shown, and minimum energy input is achieved with a flight time of 77 hours. Under these conditions the boost at point I equals 3102.3 m/s and at point F, 366 m/s, giving a total input of 3468.3 m/s. It is concluded from the relationship between Lowden's basis vector and time that flight trajectories with a flight time of less than or equal to 78 h are locally optimal; those with a flight time longer than 78 h and shorter than 89 h are not optimal; and those with a flight time equal to or greater than 89 h are locally optimal. The energy input can be reduced considerably by the optimal choice of point F.
Figures 4; references 9: 1 Russian, 8 Western.
[34-8831]

UDC 524.7-77

# POSSIBLE MODEL OF VARIABLE RADIO SOURCES WITH 'SUPERLUMINAL' MOTIONS OF VLBI COMPONENTS

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 63, No 5, Sep-Oct 86 (manuscript received 25 Mar 86) pp 874-883

[Article by B.V. Komberg, Space Research Institute, USSR Academy of Sciences]

[Abstract] The principal properties of "superluminal" VLBI components in compact variables of extragalactic radio sources are discussed, followed by an examination of the merits and shortcomings of the two models, "ballistic" and "screen," most frequently cited in the literature. A modification of the "screen" model is examined within whose framework the "superluminal" components and regions of interaction between precessional jets of relativistic plasma moving with phase velocities and medium inhomogeneities in the circumnuclear regions. Better consistency with observations is achieved by making some assumptions with respect to a "multiray" spatial section of the jet and an elongated cometary configuration of the gas inhomogeneities, the latter arising due to exposure of the cloud to a powerful supersonic "nuclear wind." The effect of "superluminal" motions within the framework of the proposed model must always be accompanied by a variability of emission in a wide range of wavelengths. This emission is caused by incidence of a precessional diagram of individual gas structures on the "rays," and therefore the "superluminal" motions phenomenon can be observed other than in the radio range. The variability of emission is for the most part not directly associated with the nucleus itself, but is generated in the circumnuclear region. "Superluminal" motions in radio structures at scales considerably greater than those discriminated from VLBI data may also be possible. These motions may be particularly significant on the periphery of extended components of radio galaxies. References 72: 16 Russian, 56 Western.

UDC 524.354

OBSERVATIONS OF X-RADIATION OF CRAB NEBULA, PULSAR NP 0532 by 'ASTRON' AUTOMATIC STATION

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 63, No 5, Sep-Oct 86 (manuscript received 18 Apr 86) pp 946-950

[Article by V.G. Kurt, M.S. Burgin, I.M. Golynskaya, L.S. Gurin, A.V. Dyachkov, V.M. Zenchenko, I.F. Kopayeva, T.A. Mizyakina, V.I. Rubanovskaya, N.A. Savelyeva, V.A. Sklyankin, A.S. Smirnov, V.M. Shamolin, Ye.Yu. Shafer, and Ye.K. Sheffer, Space Research Institute, USSR Academy of Sciences; State Astronomical Institute imeni P.K. Shternberg]

[Abstract] The source Tau X-1 was studied by the "Astron" automatic station on 1 April 1983 and 16 March 1984 using the SKR-02M X-ray telescope-spectrometer. The SKR-02M is designed for the registry of X-radiation in the range 2-25 keV. The observations of Crab nebula were made primarily for calibrating and adjusting the X-ray telescope-spectrometer. The spacing of observations 1 year apart was for checking the stability of the main parameters of the instrument complex. The "Astron" orientation system made it possible to orient the optical axis of the X-ray telescope on Tau X-1 with an accuracy of several minutes of angle and maintain this accuracy for up to 2 hours. The energy spectrum of emission of Tau X-1 was constructed using counting rate data in each of 10 energy channels. A brightness curve was also constructed for the pulsar NP 0532, also observed on 16 March 1984. These spectral measurements demonstrated that during flight the limits of the energy channels within the range 3-5 percent coincided with the values obtained during preflight calibration measurements on the surface. The emission spectrum of Crab nebula corresponded well to the Tau X-1 spectrum determined by other experimental groups. The shape of the NP 0532 brightness curve corresponded closely to that obtained from earlier observations in the range 2-25 keV. It was determined that during the period 1976-1984 there were no significant changes in the period of NP 0532 rotation. Figures 2; references: 12 Western.

UDC 523.61

STRUCTURE OF OORT COMETARY CLOUD

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 63, No 5, Sep-Oct 86 (manuscript received 1 Oct 85) pp 1040-1050

[Article by L.S. Marochnik and G.B. Sholomitskiy, Space Research Institute, USSR Academy of Sciences]

[Abstract] A study was made to clarify the possibility of direct observations of the Oort cometary cloud using the submillimeter emission of the cometary nuclei populating it. Two possible cases are examined: the sun as

solitary star and the sun as a component of a wide binary. The dependence on distance is considered, as well as the limits within which the temperature of cometary bodies in Oort's bank may vary. The degree of thermalization of an ensemble of cometary bodies in its inner and outer parts was computed. The possibility of generation of collective oscillations in the ensemble of bodies populating the Oort cloud is demonstrated. A hypothesis is proposed concerning the origin of extinction in the high galactic latitudes which relates it to the cometary reservoir surrounding the solar system. There are a number of aspects of the problem of the relationship between neutral absorption and diffuse bands and the Oort cometary cloud which remain unclarified, especially the question of the sources of an adequate quantity of dust. The dust may appear during the transits of starts or a hypothetical companion of the sun (if one exists) through the Oort cometary cloud. The observations of star extinction provide a basis for examination of these questions. This represents only the first part of the research. The second part is an examination of the emission spectrum of the cometary cloud and the angular distribution of change in the gravity field of the sun + companion wide binary. Figures 1; references 45: 4 Russian, 41 Western.

UDC 524.834

## SMALL-SCALE ANISOTROPY OF RELIC RADIATION IN NEUTRINO-DECAY MODELS OF UNIVERSE

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 63, No 6, Nov-Dec 86 (manuscript received 29 Jul 85) pp 1057-1072

[Article by P.D. Naselskiy, I.D. Novikov, and L.I. Reznitskiy, Institute of Space Research, USSR Academy of Sciences; Rostov State University]

[Abstract] A number of works have recently actively developed a new approach to the problem of the formation of the large-scale structure of the universe, based on the hypothesis of instability of massive neutrinos. This article analyzes the problem of the magnitude of small-scale anisotropy of the relic background electromagnetic radiation within the framework of neutrino-decay models of the universe, distinguished by the possibility of high density of unstable neutrinos in the era with red shift $10^3$-$10^4$ with the condition of spatial flatness of the universe. The major stages of the dynamics of expansion of the universe with unstable neutrinos are analyzed, yielding a simple analytic approximation of the results of numerical calculation in previous studies. The physical parameters of the model of adiabatic disturbances of the metrics are discussed and a number of moment equations are presented. The amplitudes of initial disturbances in the metrics are then normalized and results are presented from calculation of the correlation characteristics of small-scale background radiation anisotropy on the assumption of standard cosmological recombination of hydrogen. Finally, the role of ionization of the gamma decay channel of unstable neutrinos in the dynamics of recombination of hydrogen is discussed and results of calculation of the level of anisotropy of background radiation are summarized. Figure 1, references 23: 16 Russian, 7 Western.

UDC 523.4-36

SPECTROMETRY OF THE SMALL PLANETS. 4 VESTA: SPECTRAL AREA 0.48-0.55 μm

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 63, No 6, Nov-Dec 86 (manuscript received 27 Nov 84) pp 1179-1182

[Article by L.F. Golubeva, D.G. Pogosbekov, and D.I. Shestopalov, Shemakhinsk Astrophysical Observatory imeni N. Tusi, Azerb Academy of Sciences]

[Abstract] A spectrum of the asteroid Vesta recorded by the authors in 1981 with a resolution of 50A included a weak absorption band with a minimum near 0.5 μm, which the authors associated with the cation $Fe^{2+}$ in pyroxenes. The authors observed this asteroid once more in opposition in 1983 with greater spectral resolution. Twin absorption bands at 0.51 and 0.54 μm were found, present only in basaltic achondritic specimens. Analogous spectrophotometric measurements of S, R and U asteroids are suggested to indicate whether differentiated matter similar to that present in eucrites, howardites and diogenites is present on their surface. Figures 2, references 7: 5 Russian, 2 Western.

UDC 523.43-87

MODELING OF SPECTRAL DEPENDENCE OF THE ALBEDO OF PHOBOS AND DEIMOS

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 63, No 6, Nov-Dec 86 (manuscript received 11 Dec 84) pp 1183-1188

[Article by Yu.G. Shkuratov, N.P. Stadnikova, and S.N. Yarmolenko, Kharkov State University]

[Abstract] This article utilizes the moons of Mars as examples to present the first results of studies of the possible influence of cosmogenic factors such as meteorite bombardment and the impact of the solar wind on the spectral characteristics of carbon-containing celestial bodies without atmospheres. The spectral course of the albedo of carbonaceous chondrites and the satellites of Mars are compared with irradiated specimens of graphite in the ultraviolet portion of the spectrum. Differences among the spectra for Phobos, Deimos, carbonaceous chondrites and irradiated graphite specimens indicate the possibility of an organic film coating the surface particles of the Martian moons, possibly resulting from meteorite impacts depositing pyrocarbon substances which subsequently interact with the protons of the solar wind. Studies in the 0.2-0.3 μm area of the spectrum indirectly confirm the correctness of the assumption of existence of a film of synthesized organic matter on the surface layers of particles in the soil of the Martian moons, as well as, possibly, certain other carbon-containing cosmic bodies. Figures 3, references 8: 5 Russian, 3 Western.

UDC 521.135

# STABILITY OF LAGRANGE POINTS IN THE RESTRICTED PHOTOGRAVITATION THREE-BODY PROBLEM

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 63, No 6, Nov-Dec 86 (manuscript received 24 Dec 84) pp 1222-1229

[Article by L.G. Lukyanov, State Institute of Astronomy imeni P.K. Shternberg]

[Abstract] A previous work studied the possibility of existence of linear and triangular libration points in a circular restricted photogravitation three-body problem. This article studies the stability of these libration points. It is noted that for the assigned parameters $q_1$, $q_2$ and $\mu$, either one linear point or two triangular points may be stable, or all points may be unstable. There cannot be two stable linear points or one linear and two triangular points simultaneously. Figures 5, references 8: 7 Russian, 1 Western.

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## 'ASTRON' OBSERVATORY TO STUDY SUPERNOVA X-RADIATION

Moscow IZVESTIYA in Russian 6 Mar 87 p 6

[Article by A. Ivakhnov, correspondent]

[Abstract] The article reports on the preparation of an experiment for observing X-radiation of the supernova which was discovered recently in the Large Magellanic Cloud galaxy. Observations were made with the automatic space observatory "Astron", which has been in orbit for almost four years. A conversation is recorded with two organizers of the experiment: Vyacheslav Ivanovich Slysh, head of the astrophysics department of the USSR Academy of Sciences' Institute of Space Research, and Yevgeniy Karlovich Sheffer, senior science associate of the State Astronomy Institute imeni Shternberg. They noted that X-radiation of supernovas has been little studied as yet. Since the "Astron" is the only space observatory of its kind with an X-ray telescope, foreign astrophysicists requested their Soviet colleagues to organize observations with it as quickly as possible. The first period of communication with the space observatory took place on 4 March. Slysh mentioned that information from the supernova observations was being processed at the Crimean Astrophysical Observatory.

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## RESULTS OF BACKGROUND RADIATION STUDIES WITH 'PROGNOZ-9' SPACECRAFT

Moscow KRASNAYA ZVEZDA in Russian 19 Dec 86 p 4

[Article by V. Ovcharov, correspondent]

[Excerpt] In a unique experiment called "Relikt", Soviet scientists succeeded in looking into the distant past of the universe and obtaining a radio portrait of it at the age of only one million years. Results of this experiment have been summarized at the USSR Academy of Sciences' Institute of Space Research.

The experiment was conducted with the aid of a radio telescope with record sensitivity, which was installed on board the automatic station "Prognoz-9". Results of studies of so-called relic radiation surviving from that early time indirectly confirm the well-known hypotheses of the "Big Bang" and the "Expanding Universe".

"The station 'Prognoz-9' was launched into space in early July of 1983," related I. Strukov, head of a department of the Space Research Institute and one of the experiment's directors. "The station's orbit was extremely elongated: its maximum distance from Earth was 720,000 kilometers, and the minimum distance was 380 kilometers. A radiometer on the station transmitted radio pictures of different parts of the universe to Earth until February of 1984. About 15 million such 'frames' in all were recorded. A radiation-intensity map of the celestial sphere in the 8-millimeter wave band has even been compiled from these pictures."

Strukov showed a slide which showed an elongated ellipse with spots and stripes of various colors scattered over it.

"This is how the radiothermal temperature of relic radiation is distributed in all directions of the celestial sphere. To obtain this map, we had to develop an onboard radio telescope operating on a wavelength of 8 millimeters. It had a radiometer and two antennas. One of them, a so-called horn antenna, was oriented along the axis of rotation of 'Prognoz-9' and received radiation coming from the antisolar direction. The other, a parabolic horn antenna, rotated together with the station and received radio waves from directions perpendicular to the axis of rotation. The antennas were connected to a measuring receiver.

"At the output of this receiver, a signal proportional to the difference between the temperatures of the radiation the antennas were receiving was recorded. A radio picture of an area of the universe with an angular dimension of 6 degrees was thus taken once each second. And since the station was rotating, we received thousands of pictures of each ring of the celestial sphere in succession. The radiometer's output signal was recorded by an onboard tape recorder, and this information was transmitted to Earth once every four days. The radio telescope's sensitivity made it possible to measure radiothermal contrast of only ten-thousandths of a degree between two separate points."

The information obtained in the course of the "Relikt" experiment does not contradict contemporary theories of cosmology. At the same time, the radiation-intensity map of the Soviet scientists differs substantially from a model map which was compiled previously on the basis of other data. In particular, the intensity of radio-frequency radiation is 10 times higher in the central part of the new map, on both sides of the vertical axis of symmetry.

Preparations for a new experiment, "Relikt-2", have begun at the Space Research Institute. Receivers which are even more sensitive will be employed in this experiment.

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## UPDATE ON FLIGHTS OF 'VEGA' SPACECRAFT

Moscow IZVESTIYA in Russian 16 Jan 87 p 2

[Text] The flight of the Soviet automatic interplanetary stations "Vega-1" and "Vega-2" is continuing for a third year. After completing comprehensive studies of the planet Venus and Halley's Comet, they are continuing to move in a heliocentric orbit between the orbits of Earth and Venus.

Radio communications with the stations are being conducted regularly, in the course of which flight-path parameters are being measured, the condition of service and scientific instrumentation is being monitored, and parameters of the interplanetary medium are being measured for the purpose of studying the propagation of disturbances caused by active processes on the sun.

According to telemetry data, the onboard systems and main scientific instruments of the spacecraft are functioning normally. The scientific information obtained from the orbits is being processed and studied.

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# FINAL PHASE OF PROJECT VEGA

Moscow SOVREMENNYYE POSTIZHENIYA KOSMONAVTIKI (NOVOYE V ZHIZNI, NAUKE, TEKHNIKE: SERIYA KOSMONAVTIKA, ASTRONOMIYA) in Russian No 12, Dec 86 pp 17-34

[Article by V.M. Balebanov, candidate of physical-mathematical sciences, State Prize winner: "The Vega Project: the Concluding Stage"]

[Text] The Vega Project has been one of the most complex projects for research on the solar system by means of spacecraft. It consisted of three parts: research on the atmosphere and surface of Venus by means of descent space vehicles; studies of the dynamics of the atmosphere of Venus by means of aerostat sondes (these aerostats, incidentally, were the first ones in the world to be placed into the atmosphere of another planet); and flying through the gas-and-dust atmosphere (coma) and plasma envelope of Halley's comet while making an extensive set of studies.

The Vega-1 unmanned interplanetary station (AMS) (cf. the last page of the cover [not reproduced]) took off from the Baykonur space-launch complex on 15 December 1984. The Vega-2 followed it six days later. At first a course was taken toward Venus, and in June 1985 they passed near Venus one after the other. Before flying past the planet, the descent vehicles were separated from the stations and they entered the atmosphere of Venus at the escape velocity, and each of them was separated into two parts--a landing vehicle and an aerostat sonde. A series of experiments in studying the atmosphere and surface of the planet was made by means of the landing vehicle. The aerostat sondes drifted at an altitude of about 54 km and their movement was recorded for two 24-hour periods by a network of ground radio telescopes. But the program of studies of Halley's comet from on board the flight vehicle (fig 1) became without doubt the most interesting.

Commands to change the automatic stable platform of the Vega-1 AMS from the transport to the working position were issued from the Long-Range Space Communications Center on the morning of 12 February 1986. After three 24-hour periods the same operation was performed with the Vega-2. Then work on observation of Jupiter began. Its purpose was to calibrate and align the television system and to check its interaction with the platform.

Television system studies relating to the observation of Jupiter were performed alternately from each AMS for several days. Color images of the planet were obtained from a distance of approximately 800 million km.

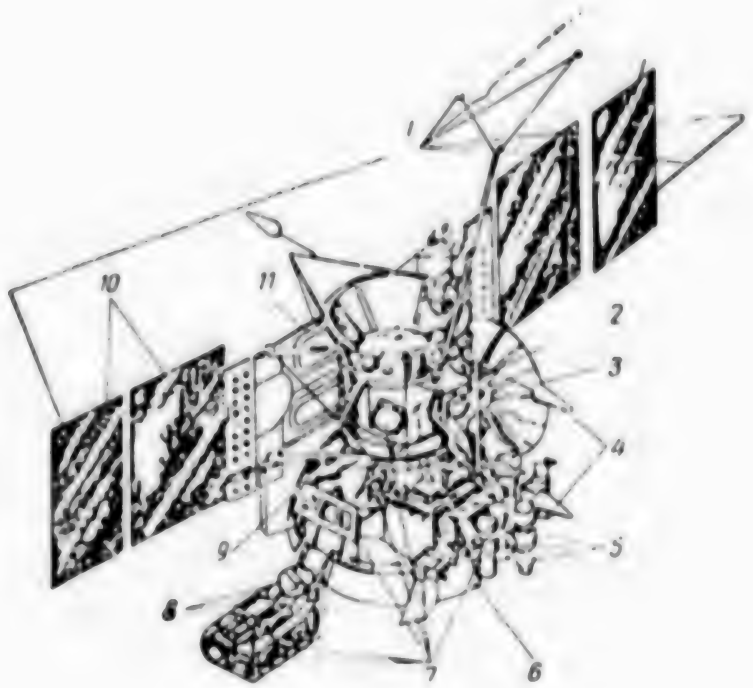


Figure 1. Vega AMS Flight Vehicle: 1, 7--scientific equipment; 2--block of tanks with power plant; 3--pencil-beam antenna; 4--small-beam antennas; 5--star-tracker block; 6--dust shield; 8--automatic stable platform; 9--instrument container; 10--solar battery panels; 11--radiator-cooler

The basis of the television system developed jointly by specialists from the USSR, Hungary and France is its image receivers, having Soviet-made arrays of microscopic silicon photocells which convert video information into an electrical signal convenient for transmission to the earth. Each such array, measuring 10 x 10 mm, contains about 300,000 cells. And the size of each cell equals 18 x 24 micrometers.

The television system consists of two cameras--a long-focus and short-focus (fig 2). Details measuring about 100 m can be distinguished at a distance of 10,000 km by means of the long-focus camera. The short-focus, having slightly worse resolution, has a wider field of view; therefore, it finds the nucleus of the comet more quickly, i.e., its brightest part, and, sending signals to the rotating platform, holds it in the field of view of the long-focus camera.

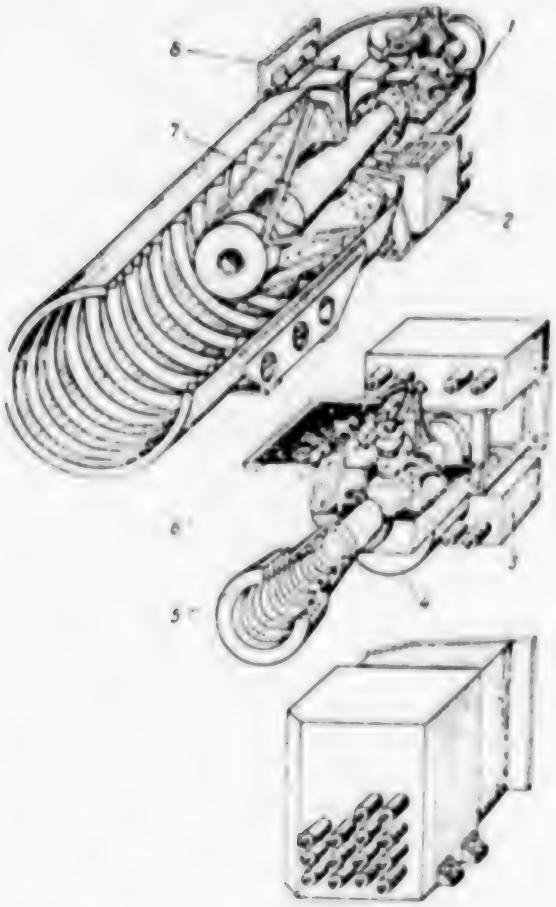


Figure 2. Television System of Vega AMS (top: high resolution narrow angle camera; center: wide angle camera guidance sensor; bottom: television system electronics; 5: lens; 6: radiator; 7: lens; 8: radiator

The AMS's television system contains a microprocessor which controls the operation of the cameras. It preprocesses the images, selects the channels and filters, and determines the exposure. Since pictures had to be taken in several regions of the spectrum, this made it possible to synthesize on the earth color images of the comet.

Instruments which were to make it possible to make detailed spectroscopic studies of the chemical composition of various regions of the atmosphere (coma) and tail of the comet are also contained in the optical system installed on the platform (fig 3), in addition to the television system. These include a three channel spectrometer developed and made through the cooperation of scientific institutions in Bulgaria, the USSR and France, and

an infrared spectrometer developed and made in France. Tests of the infrared spectrometer were made in the USSR jointly by French and Soviet specialists. Interpretation of the data was also to have been done jointly.

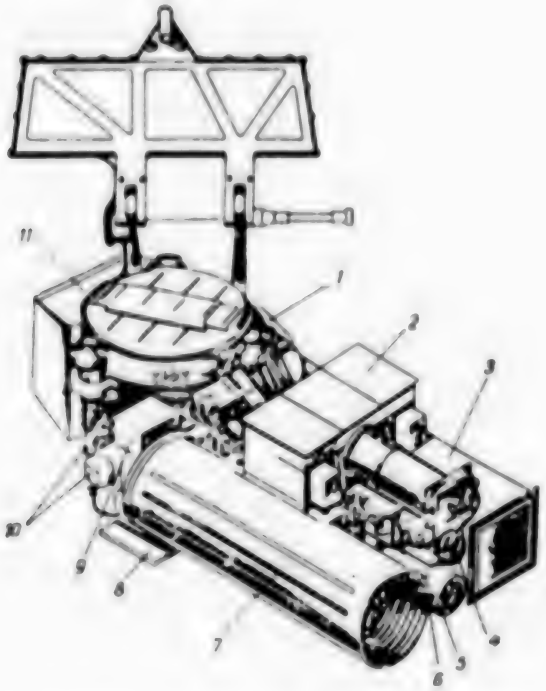


Figure 3. Automatic Stable Platform with Scientific Apparatus: 1--television unit electronics; 2--three-channel spectrometer; 3--infrared spectrometer; 4--analog guidance sensor; 5--television guidance sensor; 6--television guidance sensor radiator cooler; 7--narrow-angle television camera; 8--narrow-angle television camera radiator-cooler; 9--narrow-angle television camera electronics; 10--photoelectric converter cooling unit; 11--automatic platform control logic unit

One of the most important goals of this research is to find primary, or, as they are still called, "parent" molecules. "Daughter," i.e., secondary, molecules are easily identified by means of ground spectroscopic measurements. But "parent" molecules have not once been observed up to now. The fact is that when the comet ice goes from the solid state directly to the gaseous, the gas is emitted from the comet's surface almost at the speed of sound, and its density is very great in the region of the nucleus. Therefore, the molecules react with one another intensely, and important chemical changes occur in them. "Daughter" molecules form in the course of these processes.

It is precisely the study of "parent" molecules which makes it possible to get an idea of the composition of the primary gas-and-dust nebula from which our planetary system was formed. Optical investigations of the gas composition of

the comet's atmosphere were to have been supplemented by measurements of it by means of a neutral-gas mass spectrometer (NMG) developed in the FRG with the participation of specialists from the VNR [Hungarian People's Republic] and USSR.

A comet's atmosphere consists not only of gas, but also of dust particles. This dust represents a great danger with a relative closing rate of a spacecraft with a comet of almost 80 km/s. Therefore, it was necessary to develop special multilayer shields in order to protect the spacecraft from collisions with these particles. At the same time it is very interesting to determine the composition of these dust particles. It was exactly for this purpose that it was decided to take advantage of their high speed. If a target is placed in the path of such a particle, then in colliding with it the particle is explosively vaporized and is transformed into a plasma cloud. A mass analyzer determines its composition and, consequently, the composition of the nucleus of the comet from which this particle was torn out. This was the idea of the PUMA experiment. The instrument for these purposes was developed jointly by specialists from the USSR, FRG and France.

A number of other instruments were intended for measuring the physical characteristics of a dust stream: the number of particles of various masses, their dimensions and density. Various effects were utilized for these measurements, including the piezoelectric, ionization and light flashes in collision, and the change in the luminous flux from the sun when piercing a thin film. All these instruments were developed by Soviet specialists.

Photoionization of the gas leaving the nucleus results in the formation around it of a plasma envelope (ionosphere) consisting of ionized molecules. The ions move together with the neutral gas at a speed of about 1 km/s; but this motion obeys different laws. No other forces act on the neutral gas than gravity and light pressure. But the solar wind "exerts pressure" on comet ions. A shock wave must form, the magnetic field must be strengthened, and wave processes accompanied by electromagnetic oscillations must originate when the solar wind encounters a comet ionosphere. The acceleration of comet ions to high energies can occur in the magnetic field of the solar wind.

Carefully thought out sets of instruments were placed on the Vega 1 and Vega 2 AMS's for the purpose of studying these processes. One of these instruments is the MISHA magnetometer developed by Austrian scientists. And later the PLAZMAG comet plasma spectrometer, developed for studies of the concentration, composition and energy of ions of both the solar wind and a comet plasma.

The TYUNDE-M energetic particle spectrometer was intended for the detection of high energy ions accelerated by the magnetic field of the solar wind. Two instruments were developed for the registration of plasma waves, both low frequency (PNR [Polish People's Republic], USSR and CSSR) and high frequency (USSR and France). The analysis of the results of measurements made by means of the instruments of the plasma complex was to have considerably refined ideas concerning the complex phenomena occurring in interaction of the solar wind with a comet.

The Vega 1 AMS was the first to arrive at the space finish line. The first comet show began early in the morning on 4 March 1986 on the 444 th day of the Vega 1's flight. At this time about 14 million km separated the celestial wanderess and the spacecraft. The television camera took the first picture of the comet. But the radio waves brought it to the earth, the distance to which equaled 191 million km, in nine minutes. still long for all at the IKI AN SSSR [Institute of Space Research, USSR Academy of Sciences] at that time. And there it was the comet. It appeared on display screens in symbolic colors, which make it possible to delineate more distinctly regions of it different in terms of structure. The center where the nucleus should be is a red spot; then an orange ring, yellow, green and then dark green, and, finally, a vast dark blue aureole - the most rarefied part of the comet's head. The intensity of the color depends on the extent of reflection of the sun's light by particles of the coma.

The second comet show began on the morning of 5 March. The Vega 1 was able to surmount in 24 hours half of the remaining distance to the comet, and now the distance from it equaled 7 million km. And Halley's comet again appeared on the screens in all its splendor. The exposure time and filters were changed, which makes it possible to reveal various details of the image and to obtain a set of photos each of which is most informative for a specific purpose.

And, finally, 6 March the culmination day of the Vega 1 AMS's flight. In order to monitor the dynamics of the comet's nucleus, the communication session began long before minimum closing of the spacecraft with the comet. The guidance system operated very well the comet was in the center of the frame at all times. The gas and dust envelope was clearly visible; it was delineated particularly well on the sunlit side.

The PUMA instrument, the infrared spectrometer and PLAZMAG were turned on. Strong oscillations in the temperature and plasma of the solar wind were observed with a period of 20 to 30 s. Nothing like this was observed during the entire time of the flight, and it is not clear whether this was the influence of the comet or fluctuations in the solar wind itself. Later analysis of the measurement data demonstrated that the transition from undisturbed streams of a relatively cold solar wind plasma to the region of a disturbed, strongly heated, comet plasma occurs at a distance of approximately 1 million km from the nucleus. And the solar wind streams stop completely at a distance of about 100,000 km, encountering some obstacle the nature of which is still to be determined.

The magnetic measurements made by means of the MISHA magnetometer were an excellent indicator of the behavior of the solar wind plasma and of its interaction with the comet. The magnetic field proved to be an order of magnitude greater at a distance of 10,000 km than in the free solar wind.

The TYUNDE M energetic particle spectrometer registered particles of comet origin having entered the plasma stream and having acquired great kinetic energy.

As far as neutral particles around the nucleus of the comet are concerned, the distribution obtained for them was in accordance with the theoretical models, but the concentration of the gas proved to be considerably greater--it equaled 10,000 particles per cubic centimeter at a distance of 1 million km.

Good spectra were obtained by means of the infrared spectrometer. They immediately showed, in the center portion of the coma, the presence of a double, very hot source of radiation in the 5.2- to 12-micrometer region of the spectrum, corresponding to the radiation of an absolute blackbody having a temperature of about 330 deg K. The length of this source was estimated to be 5 to 7 km, and it had an irregular configuration.

It followed from ground measurements that when the spacecraft passed through the coma it could encounter a large number of particles about 0.1 mm in diameter and weighing millionths of a gram, and particles weighing thousandths of a gram would be encountered with 10-percent probability. Collisions with dust particles began to be registered at a distance of about 750,000 km from the nucleus, and their mass at first did not exceed $10^{-13}$ to $10^{-15}$ g. And on the whole the flux turned out to be at least 10-fold lower than expected. Unexpectedly, there were many particles having a mass of less than $10^{-16}$ g.

Even before maximum closing with the nucleus, approximately 160 s prior to it, the stream of dust particles began to pulsate. In the process the number of dust particles immediately increased dozens of times, reaching 1000 and more collisions per second per square decimeter. The spacecraft periodically passed through regions of increased dust density separated in space by distances of 300 to 500 km.

Encounters with individual particles having a mass of greater than $10^{-6}$ g were registered closer to the nucleus. The solar batteries had their power reduced by almost one half on account of partial failure of their cells after passing through the comet dust.

When the spacecraft passed at the minimum distance from the nucleus its precise boundaries could not be seen. Debates also arose: Some saw one nucleus, and others two. And this is totally explainable. Imagine that you are in a motor vehicle which is speeding along at about 40 km/s. Note: not per hour, but per second. And another car behind whose wheel a pretty girl is sitting is dashing toward you at the same speed in clouds of dust. And you try to make her out. The television system of the Vega-1 AMS faced a similar problem. Add to this a distance between the spacecraft and the comet of 8889 km (as it was at the moment of maximum closing at 10 h 20 min 6 s, Moscow time, on 6 March) and stones which are flying out from under the wheels of the oncoming car and can smash your car to pieces.

The conclusion which the scientists arrived at preliminarily was that a certain formation of irregular shape, amorphous in appearance, measuring from 6 to 10 km along its major axis and having a very low albedo, was observed in the center portion of the coma. It is surrounded by a considerable number of dust particles, by a kind of coat, which masks the surface of the nucleus. The analysis was complicated still more by the fact that because of its irregular shape the "nucleus" was illuminated variously by the sun and jet

outflows of dust originated. The instruments of the Vega 2 AMS were to have said whether this was correct or not.

On 7 March 1986 communication sessions were held alternately with the Vega 2 AMS, which neared the comet to a distance of 14 million km, and the Vega 1 AMS, which by this time was 7 million km away from the nucleus. The comet was photographed both from the head and tail practically simultaneously. And on 9 March 1986 the culmination moment of the flight came for the Vega 2 AMS, too. It passed at a distance of 8030 km from the comet's nucleus at 10 h 20 min. Moscow time.

It was known that the comet's nucleus rotates. Furthermore, one side of it is more active. The Vega 1 AMS flew through precisely on this active side. The Vega 2 AMS faced the "quiet" side. And dust particles were registered at a distance closer to the comet than in the preceding flight. The number of dust ejections was also considerably lower. A few particulates per second were registered 5 min before maximum closing, and then 20, 30 and 50. The instruments portrayed the peak and then the number of particles decreased smoothly.

Processes of the interaction of the solar wind plasma with the comet were registered at a closer distance to the comet.

Very interesting results were obtained by means of the three-channel spectrometer. It began to operate a long time before the flight up to the comet. Excellent spectra were obtained in the visible and infrared regions by its means. From these it was possible to identify several of the comet's components whose spatial resolution had never been studied in the center portion of the coma, and could not be studied by ground facilities.

The comet's nucleus was photographed full frame on the Vega 2 AMS, i.e., approximately all 300,000 of the image receiver's sensing elements took part in the job. This reduced the total number of frames transmitted to the earth, but then photographs were obtained not only of the nucleus, but also of the circumnuclear region up to distances of from 10 to 40 or 50 km. The resolution of the photographs was not in the least worsened with this. And on the whole the quality of the images obtained from the Vega 2 AMS was higher than in the preceding flight. The nucleus's boundaries were outlined rather distinctly on the photographs obtained at the moment of closing with the nucleus.

Of course, the Vega Project was a component of the broader international program of research on Halley's comet. On 8 March 1986 the Japanese Suisei spacecraft passed at a distance of 150,000 km from the nucleus of the celestial wanderess. Its principal objective was studies of the comet in the ultraviolet region of the spectrum. In this region the comet is observed as a sphere having a diameter of a few million kilometers. Furthermore, its form and dimensions vary with a period of approximately slightly more than two days. This is obviously associated with rotation of the comet's nucleus. The entire program of experiments was completed successfully by the Japanese spacecraft. And on the night of 13-14 March 1986 the West European Giotto

probe approached the comet. Its guidance was accomplished from the results of the Vega AMS flight.

The error in determination of the comet's position was reduced considerably after the flight of the Vega-1 AMS. And after the flight of the Vega-2 AMS, as noted by West European Space Agency Scientific Program Director R. Bonne, it was literally brought down to a few dozen kilometers.

According to the original agreement, Soviet scientists were to have transmitted all the necessary data to the Giotto flight control center in Darmstadt (FRG) 48 h after the flight of the Vega-1 AMS. West European scientists came with the request that the data be given out after 32 h, and they received the data after 26 h.

The Giotto spacecraft is considerably smaller than the Vega AMS but is furnished with a thicker dust shield, which made it possible for it to come considerably closer to the comet's nucleus. Some of the scientific instruments of the Giotto are very similar to the instruments of the Vega AMS's. In particular, in it was the dust collision mass analyzer (PUMA), on which the same group of scientists from the FRG worked as in the Vega Project. There was also the set of instruments for plasma studies. However, in the Giotto its "eyes" were designed more simply: There are no spectrometers, and the image obtaining system is based on the principle of mechanical scanning - a line of receiving elements, and the composition of the lines is made possible by rotation of the spacecraft. Without going into the details of the Giotto's scientific equipment, let us note that both scientific programs complemented one another.

The Giotto's information arrived right to a distance on the order of slightly greater than 2000 km from the nucleus. Then the spacecraft reversed as the result of a large dust particle's having struck it, and communication with it was lost and resumed only when it had already passed at the minimum distance from the nucleus of approximately 540 km.

A rapid analysis of the images of the comet's nucleus transmitted from the Giotto confirmed its principal characteristics found from the Vega AMS data.

Plasma measurements demonstrated that the magnetic field disappears at a distance of 500 km, and a "magnetic void" forms in the immediate vicinity of the nucleus. Its existence was predicted by the theory, and the Giotto measurements made it possible to confirm this hypothesis for the first time.

But what can be said about the results of the research done by means of the Vega 1 and Vega-2 AMS's?

The scientists involved in analyzing the photographs of Halley's comet obtained from on board the AMS's came to the conclusion that the comet's nucleus is in the form of an irregularly shaped prolate monolithic body. Its maximum dimension along its greatest axis is estimated to be 14 km, and about 7 km across. Some compare the shape of the nucleus with a potato tuber, others with a peanut (Arachis), others with a banana, and others with a worn-down shoe. The nucleus has very low reflectance.

Let us recall that until recently three most probable hypotheses existed for the physical structure of the comet's nucleus.

First of all, a model describing the nucleus as a single solid consisting of an agglomeration of frozen gases and rocky meteoritc material. According to another hypothesis, the nucleus is a dense cluster of various particles. Finally, the nucleus is many small particles bound together by gravity. The hypothesis that the comet is a "flying iceberg" was used for development of the engineering model of the comet for the Vega Project. And it was confirmed. A double or more complex multiple structure (several separate bodies) has almost been ruled out.

Volatile matter and ice, which determine 'he specifics of the comet's behavior, are mixed in the nucleus with a high-melting material which it has in its surface layer. The thickness of this high-melting layer is from one to several centimeters.

Comparison of the images obtained from the two spacecraft made it possible to estimate the nucleus's period of rotation--one rotation in 50 to 55 hours. The angle of inclination of the equator to the orbital plane is less than 15 deg.

Measurements obtained by the infrared spectrometer showed that the surface of the nucleus is hot--approximately 100 deg C. This is much higher than was predicted for the ice model. In the opinion of scientists, the reason for such a high infrared temperature is an insulating layer of a surface, porous, black, high-melting material This layer receives the sun's rays, re-emits part of them in the infrared band, and transfers part to the ice blob. Water vapor molecules formed as the result of evaporation diffuse through the pores upward and leave the comet. With this they entrain individual finer dust particles. The surface layer breaks open from time to time in individual places, and then an active region forms with particularly heavy discharge of matter.

The head of the planetary physics department of IKI AN SSSR, Professor V.I. Moroz, suggests that a March snowdrift on a city street can be considered an analogue of a comet's nucleus, in strongly reduced form, of course. A layer of dirt covering it can be heated to high temperatures on sunny days, and at the same time for a long time it keeps the snowdrift from thawing.

The high-melting surface layer of the comet's nucleus is very quickly restored (in approximately 24 hours). Its upper layers are torn off and carried away by gas, but new ones adhere below. In the process its thickness should gradually increase and, ultimately, after a certain time apparently numbered in tens and hundreds of thousands of years, the comet can lose its activity and become an asteroid.

According to the data of the Vega 1 and Vega-2 AMS's, on the order of 40 t of water were evaporated from the surface of the nucleus on the whole each second. Measurements by the PLAZMAG instrument showed that the component

second in abundance is carbon dioxide, but there are many other components too, atomic and molecular.

The emission bands of approximately ten molecular components (carbon monoxide and dioxide, hydroxyl, cyanogen, etc.) were registered in the inner coma by means of the infrared and three-channel spectrometers.

Let us recall that astronomers have studied comets for already about 100 years by means of spectral instruments connected to telescopes. It is precisely such observations which have provided the lion's share of today's ideas about comets. They were made first by means of visual spectrometers, then they changed to photographic instruments, and then to photoelectric recording spectrometers.

Two components can be isolated in the spectra of comets: the continuous spectrum and emission bands. The continuous spectrum is due to the scattering of solar light in microscopic particulates which are present in the coma and tail. The bands originate as the result of a physical process which is called resonance fluorescence. It consists in the fact that molecules, as well as atoms and ions, absorb solar quanta at wavelengths corresponding to transitions between energy states characteristic of a given molecule, and after small fractions of a second a return occurs to the initial state with the emission of a quantum at the same wavelength. As a result, by observing the spectra it is possible to obtain information on the quantity of various molecules, atoms and ions, as well as of dust particles in various parts of the comet.

The placing of spectral instruments on board spacecraft provides great advantages as compared with ground observations. Measurements were made at a short distance from the coma and directly inside the coma, which made it possible to analyze the emission from inner regions of the comet inaccessible to ground research. The employment of two spectral instruments or, more precisely, complexes, made it possible to make studies over a very wide waveband.

Of special interest now is the question of which molecules of those recorded by these instruments belong to the class of "parent" molecules, i.e. those directly making up part of the nucleus. Apparently, the principal ones among them are water and carbon dioxide, but there is much to indicate the presence in the nucleus of other molecules, too, including organic ones.

As far as bands of secondary molecules are concerned, the majority of them were registered previously from the earth. However, the powerful hydroxyl emission turned out to be unexpected. It is not explained by the usual fluorescence process, which was discussed above, but originates as the result of chemical excitation in the dissociation of water vapor molecules. This emission was observed for the first time.

Let us note that the spectra were recorded with very high spatial resolution, hundreds of times better than can be done from the earth. This advantage will make it possible, in further analysis of the data, as expected, to refine

considerably ideas concerning chemical processes in the comet gas directly near the nucleus.

The spectrum of the solar radiation scattered by the comet dust was analyzed together with the data of the dust counters which recorded collisions of particles. The best agreement of optical and direct measurements is obtained if a density considerably less (severalfold) than one is used for the particles. This means that comet particulates have a porous structure. Similar particles are found on the surface of the earth, and hypotheses have been advanced that they are samples of comet dust.

Thus, the material of the nucleus most likely represents a so-called "clathrate," i.e., ordinary water ice into whose crystal lattice other molecules have been "impregnated." Particles of meteoritic composition, and stone and metallic particles are mixed with the clathrate. The chemical composition of solid particles which make up part of the nucleus but which left it under the pressure of gas streams was measured on the flight path of the Vega-1 and Vega-2 AMS's by means of the dust collision mass analyzer.

The composition of the particles turned out to be very complex and nonuniform. There are particles having a predominance of metals such as sodium, magnesium, potassium and iron, and others having a silicate impurity. Oxygen and hydrogen peaks indicating the presence of water molecules are often seen in the mass spectra. Finally, there are particulates in which a considerable amount of carbon is present in addition to metals. The presence of various kinds of particulates indicates a complex thermal history of the primary material of the solar system.

"As a result of the Vega-2 AMS expedition," the project's scientific director, Academician R.Z. Sagdeyev, noted, "scientists saw the nucleus for the first time, obtained a great amount of data on its composition and physical characteristics, made a choice in favor of one theoretical model, and refined it considerably. The rough sketch was replaced by a picture of a real natural object never observed previously. Externally it is reminiscent of the Mars satellites Phobos and Demos, but certain small satellites of Saturn and Uranus can turn out to be an even closer analogue. This fits into the framework of the hypothesis to the effect that comet nuclei formed relatively close to the sun, approximately where the giant planets from Jupiter to Neptune are located, and were thrown great distances in the formation of these planets."

In addition to studies of the chemical composition of particulates, measurements were made from on board the stations of the quantitative characteristics of the dust stream--special counters determined the number of collisions of particles of various masses and their paths, and estimates were made of the distribution of particles by mass as a function of distance from the comet's nucleus.

One of these counters--it was called the DUSMA--was developed jointly by Soviet specialists and American scientists (from the University of Chicago). The scientific director of the experiment on the American side, Professor (Dzh.) Simpson, characterized the sensitivity of the DUSMA instrument this

vividly: "The finest of the comet dust particles registered is ten times smaller than cigarette smoke particulates."

Experiments with dust counters demonstrated that about one million tons of dust leaves the comet nucleus every 24 hours. Its flux is nonuniform: it is greater above active regions of the nucleus. In addition, there are effects associated with the distinct influence of light pressure on the motion of particles of various masses and dimensions. The nature of the distribution of particles by size turned out to be quite unexpected: An unusually large number of small particles of a size on the order of 0.01 micrometer were detected.

As demonstrated by measurements made by the instruments of the Vega 1 and Vega 2 AMS plasma complex, the gas evaporated from the comet's nucleus and diffused into the interplanetary medium at a speed of about 1 km/s is in the final analysis totally ionized by solar radiation. As a result, a gigantic plasma formation originates which measures about one million kilometers and creates an obstacle in the path of the supersonic stream of the solar wind. Even the magnetosphere of the earth is 10 to 15-fold smaller.

A peculiar shock wave, unlike in terms of its structure the well studied shock waves in front of the earth and other planets, forms in front of the comet in the supersonic stream of the solar plasma. Direct measurements of the plasma and plasma waves in the inner part of the coma from on board the Vega AMS's will make it possible to understand the distinctive features of formation of the plasma and the emission of gas not only in comets, but also in a number of other astrophysical objects in which the interaction of plasmas plays a large role.

Analysis of the results of the Venus - Halley's Comet Project is far from having been completed. At first each group of experimenters is working chiefly with "its own" data. A detailed cross analysis of data obtained by various methods - both optical ground and direct - should become most interesting. Surely one principal feature of the present research on Halley's comet is broad and active international cooperation. Here there have been both the joint development of instruments, and mutual assistance in the implementation of projects, and a common "ground astronomical observation data bank." And all the traditions of international cooperation formed in the process of preparation and implementation of the studies are being totally preserved also at the data processing stage.



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## VENUSIAN SURFACE AND CRUST

Moscow ZEMLYA I VSELENNAYA in Russian No 4, Jul-Aug 86 pp 3-15

[Article by V. L. Barsukov, corresponding member, USSR Academy of Sciences, and Yu. A. Surkov, professor]

[Text] As is well known, the flights of spacecraft to Venus and investigations of Venus from the earth's surface have made it possible to develop new concepts concerning its surface and rocks (their composition, structure and properties). These ideas are based primarily on four panoramic images of the surface and investigation of the elemental composition and physical characteristics of rocks in seven regions of station landings. In addition, definite information on rocks was obtained on the basis of composition of the near-surface atmosphere and also on the basis of the physical and climatic conditions near the surface. Finally, an important contribution has been made by radar studies of macroscale geological structures. During the last two decades all this has made possible a considerable broadening of concepts concerning the Venusian surface and crust, despite the thick atmosphere, dense cloud cover and severe climatic conditions on the planet.

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### Radar Research From Earth

Modern radio telescopes usually operate at wavelengths from 1 to 30-60 mm within the limits of transparency of the earth's atmosphere. (Waves of a lesser length are absorbed by oxygen and water vapor, waves of a greater wavelength become impenetrable for the ionosphere.) A radar map of the Venusian surface was also compiled on the basis of the strength of the reflected signal. This type of measurement, in combination with measurement of polarization of the reflected signal, make it possible to determine permittivity and permeability, density, surface relief, etc. However, the map based on surface radar measurements is incomplete; it is limited to longitudes from 0° to -80° and latitudes from -50° to +40°. The best resolution is obtained in the equatorial part of the planet.

The first radar studies of Venus were made almost 20 years ago. It was possible to detect a great difference in the reflectivity of different regions on the Venusian surface. The observed radio bright and radio dark surface

regions are evidence for the most part of differences in topography and finely disperse roughness (irregularities) and to a lesser degree -- of the physical properties of the surface. During recent years interest in radar observations of Venus has increased appreciably. Radar images and altimeter sections of some surface regions have been obtained. Vertical radar resolution was about 100 m and surface resolution was 10 km near the equator and 100 km near the poles. By this method it was possible to investigate the equatorial part of the planet bounded by latitudes $\pm 40°$ with a more or less acceptable resolution.

Images of individual small regions with a high resolution made it possible to detect large structures resembling craters, canyons and valleys. Most of them are evidently of a shallow depth. In particular, it was found that a crater with a diameter of 160 km has a depth of only 500 m. This is almost an order of magnitude less than the depth of craters of similar diameter on the moon. If the mentioned structures consisted of the same rocks as the lunar craters, they must have been formed in an early epoch of Venusian development and their existence indicates that the processes modifying the Venusian surface did not transpire as effectively as on the earth.

An extremely intriguing structure was discovered: this was a gigantic trench-like depression extending for a distance of 1,400 km and having a width up to 150 km and a depth as great as 2 km. Such formations may be evidence of strong tectonic activity on Venus not only in the past, but also at the present time.

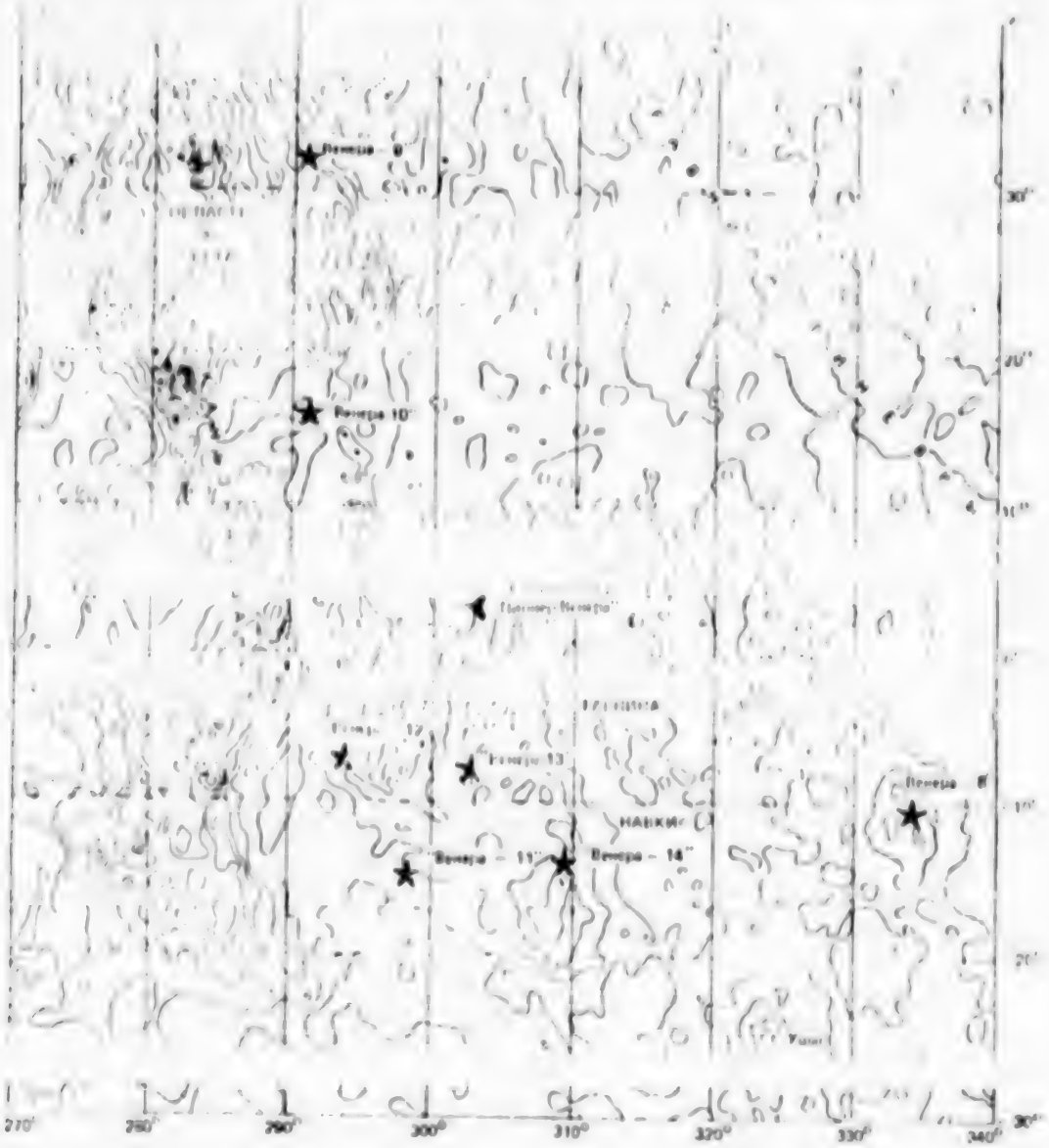
Thus, radar images on the one hand indicate the existence of ancient regions which evidently have changed little since the time of formation of craters of impact origin in them, and on the other hand, these images give a number of proofs that Venus is a geologically active planet. Here geological structures are formed which with respect to diversity are almost equivalent of those on the earth. For the time being such contradictory circumstances have no convincing explanation due to the inadequacy of factual material.

Radar Investigations by Orbital Vehicles

The altimetric measurements and radar images obtained by the American space vehicle "Pioneer-Venus" constituted the next step in comprehension of the global characteristics of topography, relief, regional morphology and chronology of formation of the Venusian surface. This made it possible to draw some conclusions concerning history of the crust and planet as a whole. The resolution of the new images was approximately the same as for those obtained by surface methods but a considerably greater part of the planetary surface was surveyed. As a comparison we point out that the resolution was less by a factor of almost 20 than that which was used in its time in compiling a lunar map on the basis of telescopic data.

The American scientist G. Mazursky, after analyzing the results of radar (surface and orbital) investigations of Venus, reduced the entire diversity of relief features to three principal types of provinces: uplifted hilly plains, constituting approximately 65% of the surface; high-mountain regions occupying

about 8% of the surface and smooth lowlands constituting approximately one-quarter of the entire area surveyed by the "Pioneer-Venus" spacecraft.




Relief map of Venusian surface constructed on the basis of radar data obtained by the "Pioneer-Venus" spacecraft. The regions of landing of descent modules are indicated on the map: stars -- Soviet vehicles, rhombus -- large "Pioneer-Venus" probe.

The uplifted hilly plains are at a level above the mean radius of the planet. They have many craterlike structures. The density of their distribution is similar to that observed on other planets of the earth group. These plains are the ancient cratered regions of Venus.

Photomosaic of radar images of Venusian surface obtained by "Venera-15" and "Venera-16" automatic interplanetary stations. The region of diagonally intersecting ranges and valleys in the Ishtar Terra region is shown. These were formed as a result of strong tectonic dislocations in the Venusian crust. (The covered area measures 800 x 1,200 km.)

Two high-mountain complexes (Ishtar Terra and Aphrodite Terra), occupying about 10% of the planetary surface, are at an elevation from 2 to 11 km relative to the mean level. They may be sectors of a low-density crust, crowned by large volcanic structures, uplifted and covered with lava. Volcanic and tectonic features are more clearly expressed in Aphrodite Terra than in Ishtar Terra; the blurred appearance of structures in Ishtar Terra may indicate a greater age. The high-mountain regions of Venus are more similar to those on the earth than those on Mars since for the most part they are evidently isostatically compensated. A third high-mountain region forms an apparent chain of scattered (irregular) volcanic structures lying along discontinuous fault zones in the neighborhood of Beta. The radar brightness of the raylike structures, which resemble little-modified lava flows, is probably evidence that the Beta region is a recent geological formation.

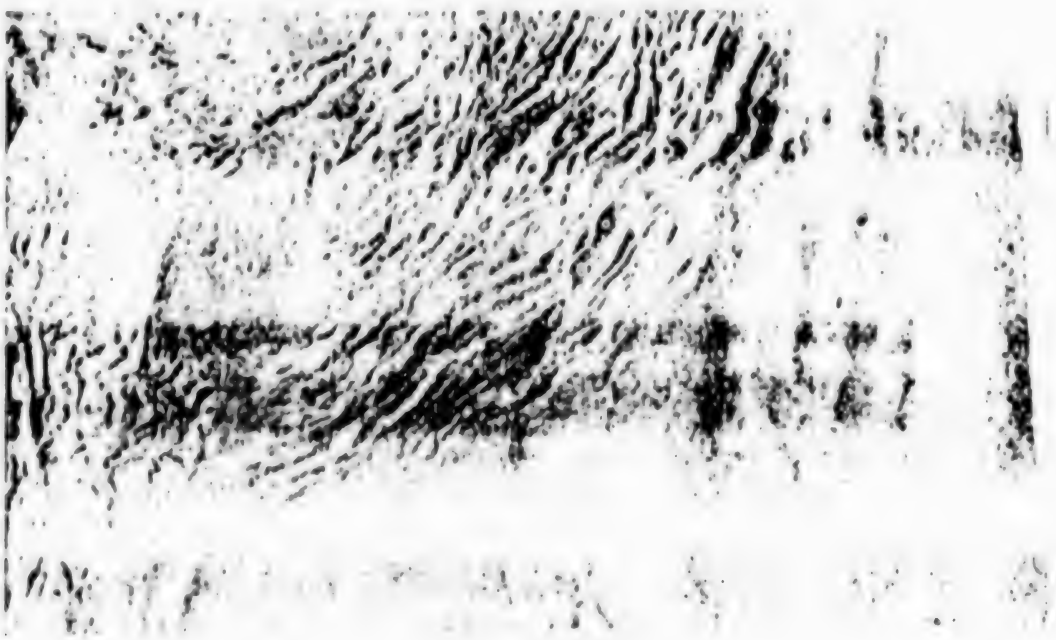
Lowlands constitute widely scattered provinces. They are situated below the mean level of the planetary surface and have a low density of craters. Some

lowlands are covered by lava flows, similar to terrestrial and lunar lowland regions.

Radar investigations carried out in 1982 by the automatic interplanetary stations "Venera-15" and "Venera-16" made it possible with a high resolution to survey a considerable part of the northern hemisphere of the Venusian surface. The resulting images made it possible to detect a mass of new geological structures which could not be observed earlier in a radar investigation of Venus by the "Pioneer-Venus" spacecraft.

Panoramas of Venusian Surface

In 1975 the automatic interplanetary stations "Venera-9" and "Venera-10" obtained the first panoramic images of the Venusian surface. The stations landed at a distance of 2,000 km apart. The landscapes were different in the landing regions.



Photomosaic of radar images of Venusian surface obtained by the automatic interplanetary stations "Venera-15" and "Venera-16." The mosaic shows Sedna plain to the south of Ishtar Terra, forming as a result of extensive outpourings of basaltic lavas. (The territory covered measures 800 x 1,200 km.)

In the place where the "Venera-9" descended there is a detrital accumulation which could have formed as a result of an eruption or might be talus. Large rock fragments lie on fine-grained material which resembles the halo surrounding the Arizona meteor crater on the earth. It should be noted that considering the dense atmosphere on Venus the fine-grained fraction should settle near the crater and only large fragments can be thrown a greater distance. Most of the fragments on the "Venera-9" panorama are of an angular configuration with

fresh and sharp edges, an indication that they were either recently formed or that erosional processes on the Venusian surface transpire slowly.

The "Venera-10" panorama shows eroded bedrock. The dark spots on the rock are probably cavities formed by bubbles. It is also possible to see fine-grained material with a low albedo of impact or eolian origin. Both panoramas indicated a landscape evidently characteristic for the look of planets having an atmosphere (Venus, Earth, Mars), in contrast to the landscape of bodies without an atmosphere (Moon, Mercury).

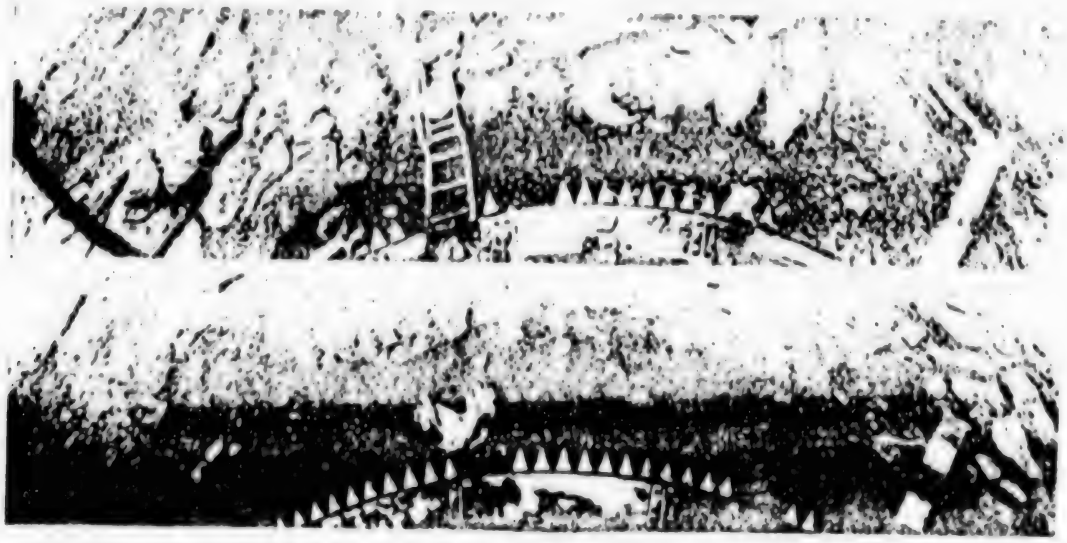
In 1982 the automatic interplanetary stations "Venera-13" and "Venera-14" transmitted new images of the Venusian surface in the landing regions. Whereas only black-and-white images with a semicircular surface scan were obtained on the "Venera-9" and "Venera-10" stations, the "Venera-13" and "Venera-14" obtained black-and-white and color (synthesized on the basis of surveys with filters) images with an almost circular surface scan. The angular resolution of the television camera on these automatic interplanetary stations was 11', which is twice as good as the angular resolution of the television cameras on the "Venera-9" and "Venera-10." With such an angular resolution it is possible to detect surface details measuring 4-5 mm in the nearest zone.

Panoramas of landing regions of "Venera-9" and "Venera-10" automatic interplanetary stations.

As indicated by the panorama of the landing region, the "Venera-13" station investigated rock in a stony desert. On the surface it is possible to see low outcrops of bedrock. The appearance of the rock shows is evidence of deep chemical weathering. In individual rock blocks it is possible to see flattened projections among the bedrock outcrops and there is a darker surface of the fine-grained surface material. The surface material is unconsolidated and it contains not only a fine-grained component, but also angular fragments of

rock measuring up to 5 cm. On the basis of the external appearance of the granular material it can be postulated that a mass of particles of insignificant size, smaller than the resolution of the telephotometer (several millimeters), is present here, that is, there is evidently also a dust fraction.

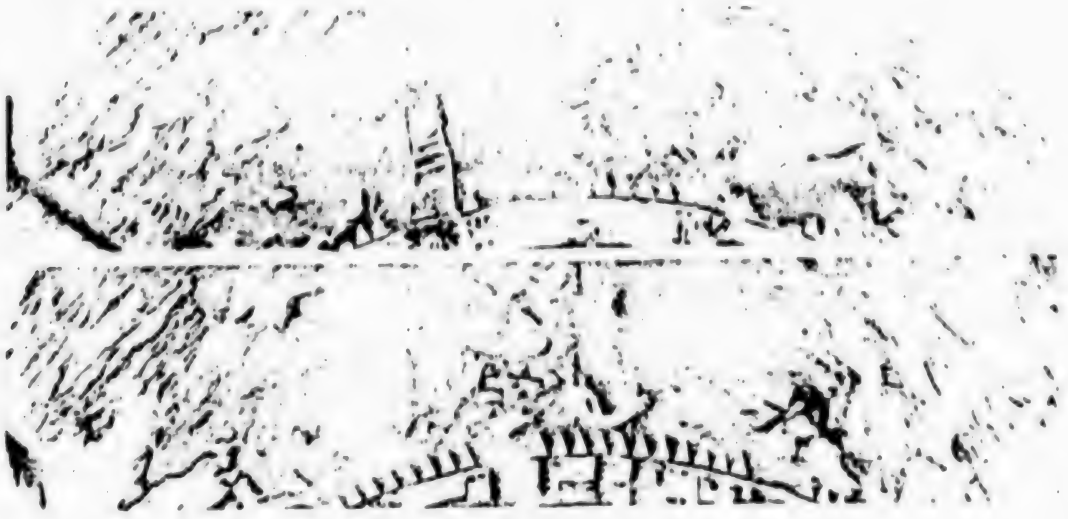
As is well known, the "Venera-9" and the "Venera-10" descended to the planet several thousands of kilometers to the east and northwest of the landing site of the "Venera-13," but also in a region of occurrence of the same structural-morphological type of surface. If a comparison is made of the panoramas obtained from the "Venera-9," "Venera-10" and "Venera-13" it can be seen immediately that the surface appearance is virtually identical. This is evidence that the relief and the type of rock itself observed on the panoramas are characteristic for the particular structural-morphological type of Venusian surface.



Panorama of landing region of "Venera-13" automatic interplanetary station.

But the panorama of the landing site of the "Venera-14" station differs somewhat from the "Venera-13" panorama. It exhibits virtually no concentrations of fine-grained dark material. The landing site itself is on a flat rocky plain which consists of rocks having a clearly expressed subhorizontal bedding. The layers differ with respect to phototone and this means they differ with respect to composition or granulometric composition. It can be seen that there are numerous layers of a small thickness with a uniform subhorizontal bedding. The stratified rocks photographed by the "Venera-14" resemble terrestrial rocks of the sedimentary type -- products of sedimentation in a calm, nonturbulent medium. On earth water serves as such a medium, but on Venus, since there is no water there, the corresponding medium might be the dense atmosphere of the planet itself. Accordingly, there must be mechanisms for the ascent of fine-grained material into the atmosphere. These mechanisms in all probability are of a global character because the bedding or layering of rocks is visible on all panoramas of the landing sites of the "Venera-9,"

"Venera-10," "Venera-13" and "Venera-14" stations, separated from one another by thousands of kilometers. Volcanic eruptions may be such a "mechanism" on Venus resulting in the ascent of unconsolidated material into the atmosphere.



Panorama of landing region of "Venera-14" automatic interplanetary station.

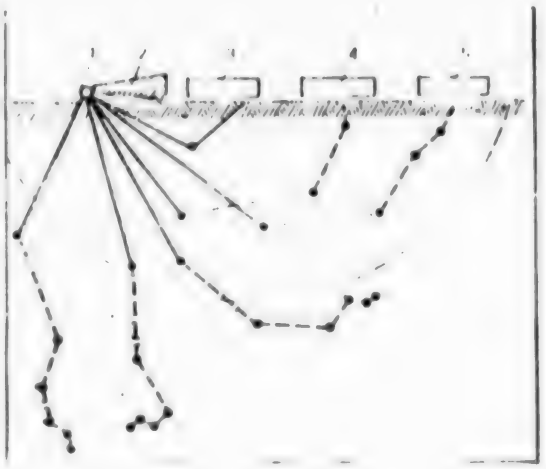


Diagram of experiment for determining rock density using radiation densimeter carried on "Venera-10" automatic interplanetary station: 1) source of $\gamma$-quanta; 3, 4, 5) detectors of $\gamma$-quanta.

All the information on the physical properties of rocks on Venus obtained by direct measurements or as a result of analysis of indirect data indicate that there are rocks on Venus which in their characteristics are close to terrestrial rocks of average density and strength -- resembling volcanic tuff or highly eroded basalt.

Already the "Venera-9" and "Venera-10" automatic interplanetary stations made it possible to obtain the first physical characteristics of Venusian rock. Instruments on the stations measured rock density by means of a radiation densimeter, its characteristics were studied from panoramas of those regions where stations landings were made and the process of collision of the densimeter sensor with the rock was also studied.

The densimeter consisted of two units -- a sensor mounted on an extensible rod outside the landing module and an electronics unit. In the sensor itself there was a radioisotopic source $^{137}Cs$, tungsten shielding and gas-discharge detectors. After the module landed the densimeter sensor was lowered onto the rock. The rock was irradiated by $\gamma$-quanta of a radioisotopic source and the backscattered $\gamma$-quanta were registered by gas-discharge detectors. Since the number of $\gamma$-quanta backscattered by the rock is proportional to rock density, the determination of density essentially involved measurement of the counting rate. As indicated by the "Venera-10" station panorama, the densimeter sensor was on a rock outcrop. It was precisely the density of this rock which was measured. It was $2.8\pm0.1$ g/cm$^3$. Such a density approximately corresponds to the density of porous basalt on the earth. However, such dense rock, judging from all available information, is by no means found everywhere on Venus; we can say that the experiments made by other stations indicate a lesser density.

The "Venera-9" and "Venera-10" also estimated rock strength. An analysis of collision of the densimeter sensor with the ground led to the conclusion that the rocks visible on the panoramas at the place of extension of the densimeter are bedrock or semi-bedrock and have a strength of hundreds of kg$\cdot$cm$^{-2}$. The rock fragments shown on the "Venera-9" panorama evidently have a somewhat lesser strength, as is indicated by their layered structure, and the splitting of part of the fragments. The region of "Venera-10" landing is characterized by more solid bedrock, as is indicated by its higher density and absence of deformation at the place where the extensible densimeter sensor was situated.

New information on the physicomechanical properties of surface material was obtained from experiments carried out with the automatic interplanetary stations "Venera-13" and "Venera-14" and the "Vega-2" spacecraft.

The carrying capacity of the ground was determined as a characteristic of its mechanical properties. The carrying capacities of Venusian ground were compared with the values obtained in simulated experiments with widely occurring terrestrial rocks. On this basis the conclusion was drawn that the ground in the landing regions of both stations can be regarded as rocks of average strength similar to sedimentary rocks on the earth.

The research on the dynamics of impact of the "Venera-13" and "Venera-14" descent modules during landing on the planetary surface confirmed those ground characteristics which were obtained using a dynamic penetrometer. Model experiments with terrestrial analogue surface materials were carried out in order to interpret the experimental results. Modeling of impact dynamics indicated that rammed sand is an analogue surface material for "Venera-13" landing

conditions, whereas for "Venera-14" it is foam concrete, although the absolute carrying capacity of the surface material for "Venera-14" was somewhat less than the estimates obtained with the dynamic penetrometer.

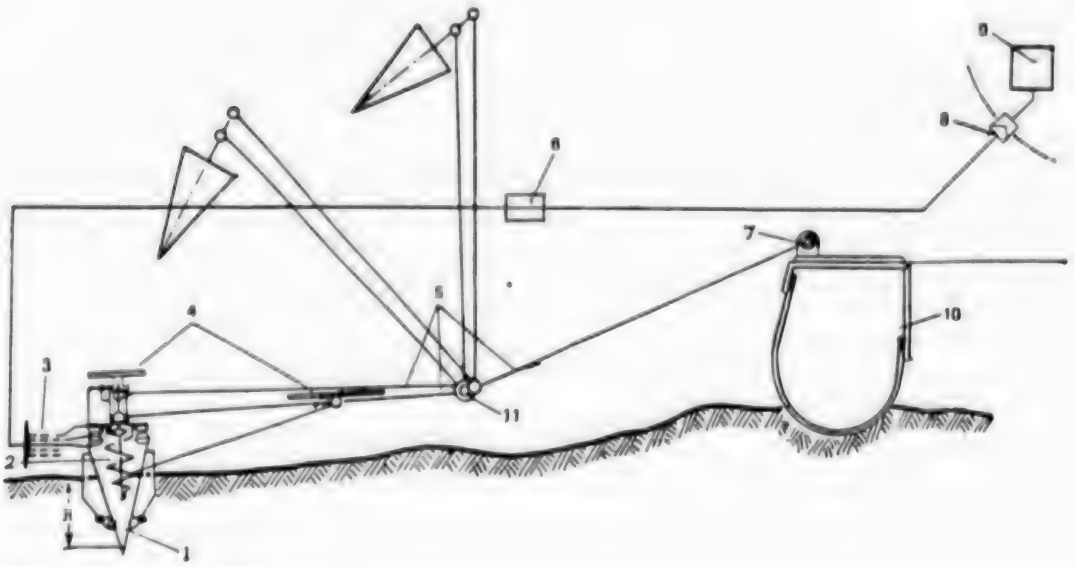



Diagram for explaining physicomechanical properties of rock using penetrometer on "Venera-13" and "Venera-14" automatic interplanetary stations and "Vega-2" spacecraft. 1) conical punch; 2) punch spring; 3) cable; 4) contact device for measuring duration of penetration process; 5) contact signaling touching of ground by punch; 6) measuring lever; 7) potentiometer; 8) lever system; 9) spring for penetration of punch; 10) spring for folding lever system; 11) landing unit.

In the course of the laboratory research necessary for determining the sampling method a study was made of the regimes for the drilling of rocks of different density. This also yielded some information on the physicomechanical properties of Venusian rocks. In particular, data were obtained on the depth of penetration of the drill into rock and the strength of the current consumed by the electric motor of the drill during its operation.

Measurements of ground conductivity were made using the "Venera-13," "Venera-14" and "Vega-2." An unusually high conductivity was discovered in the landing regions of the "Venera-13" and "Venera-14." This can be attributed only to the presence of a considerable quantity of conducting components. However, for the time being there are no other indications of their presence. A low conductivity close to the conductivity of some types of basaltic rocks at a temperature of 500°C was registered in the "Vega-2" landing region.

In summarizing some of the results we note that in the regions of landing of the "Venera-13" and "Venera-14" the rocks were similar to one another in

their physical properties. In both cases a study was evidently made of rocks of volcanic origin which in their structure resemble sedimentary rocks, but with respect to their physical characteristics correspond to weakly bound products of chemical reworking and weathering of bedrock.

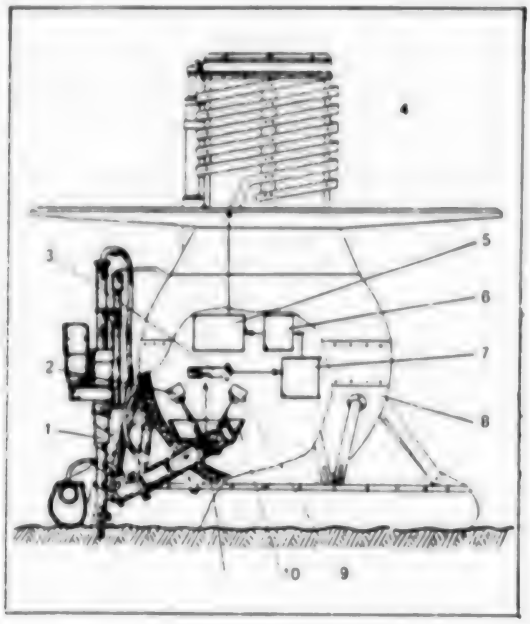



Diagram of experiment carried out with "Venera-13" and "Venera-14" for determining elemental composition of Venusian rock. 1) body of landing module; 2) block for amplifying signals and control of experiment; 3) pulse amplitude analyzer; 4) telemetric system; 5) antenna; 6) detector; 7) radioisotopic source $^{55}Fe$; 8) surface material receptacle; 9) investigated rock sample; 10) radioisotopic source $^{238}Pu$.

Natural radioactive elements. The first information on the content of natural radioactive elements in Venusian rock was obtained in 1972 with the "Venera-8" automatic interplanetary station. Later such experiments were carried out with the "Venera-9," "Venera-10," and also "Vega-1" and "Vega-2."

In order to determine the content of uranium, thorium and potassium in Venusian rocks the landing modules carried gamma spectrometers for registering gamma radiation in the energy range from 0.3 to 3.0 MeV. These spectrometers were triggered during the descent of the landing modules in the Venusian atmosphere at an altitude of 25 km above its surface and operated cyclically up to ending of functioning of the vehicles. The cyclic operation of the instruments made it possible to monitor the possible deviation of the parameters of the registered spectra, scale position and energy resolution with time, and also to trace the dynamics of decay of radioactive elements forming under the influence of cosmic radiation. Approximately 20 spectra were obtained by each landing module.

The content of natural radioactive elements, according to the results of measurements on Venus, was determined on the basis of a preliminary calibration of analogues of the gamma spectrometers carried aboard "Venera-8," "Venera-9" and "Venera-10" and the "Vega-1" and "Vega-2." The calibration was carried out under field conditions on exposures of rock with a known composition (in particular, with a known content of uranium, thorium and potassium). During the calibration measurements the instrument was placed within a mock-up of the landing module so that the conditions for calibration on the earth and measurements on Venus were close.

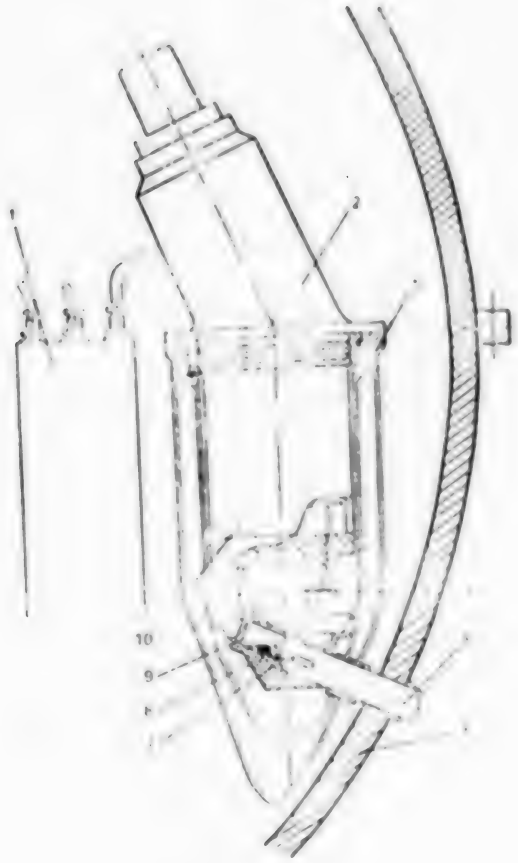


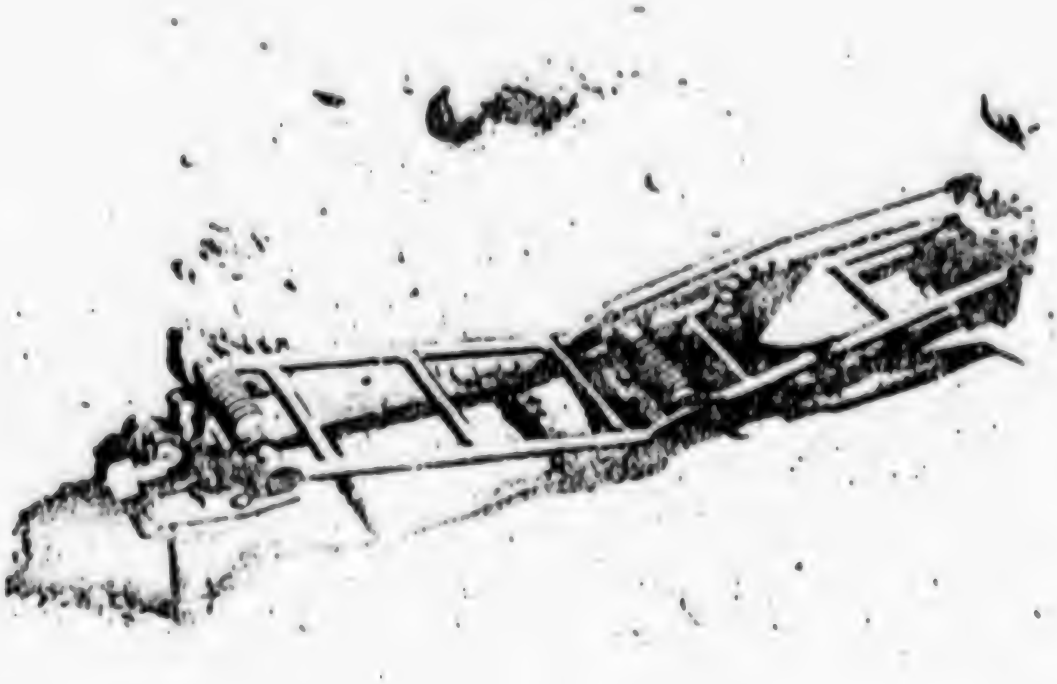
Diagram of x-ray fluorescence spectrometers carried on landing modules of "Venera-13" and "Venera-14" stations. 1) pulse amplitude analyzer; 2) cover of detection unit; 3) body of detection unit; 4) counter; 5) lock; 6) body of station landing module; 7) investigated rock sample; 8) surface material receptacle; 9) radioisotopic source; 10) electronics package for eliminating signals.

The results of the research carried out by the landing modules indicated that all the rocks, other than those which were investigated by "Venera-8," have rather close and relatively low (in comparison with the continental rocks of the earth) contents of natural radioactive elements. With respect to the content and ratio of radioactive elements in the landing regions of the "Venera-9" and "Venera-10" and "Vega-1" and "Vega-2" stations, Venusian rocks correspond most closely to the tholeiitic basalts of the earth's crust, whereas rocks in the "Venera-8" landing region correspond most closely to potassic alkaline basalts.

Rock-forming elements. The composition of the rock-forming elements was determined in the landing regions of "Venera-13," "Venera 14" and "Vega-2." The x-ray radiometric method was used for this purpose. It is based on the dependence of the intensity of the characteristic radiation excited by radioisotopic sources on the content of the analyzed element in the sample. Earlier such a method was used successfully in an investigation of the Moon and Mars.

All the analytical apparatus was situated within the pressurized and thermostated compartment of the landing module and functioned under normal climatic conditions. The miniaturized ground-sampling device took a rock sample which was then transported through a special locking channel into the descent module. The ground sampler and the mechanism for the transport of the selected

sample operated directly under those climatic conditions which exist at the planetary surface. All the operations for taking the sample and its transport involved the use of pyrotechnic devices.



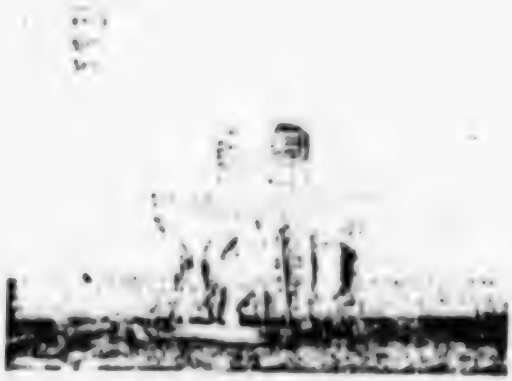
This mechanical penetrometer carried aboard the "Venera-13" and "Venera-14" automatic interplanetary stations was used in determining the strength characteristics in station landing regions.

The landing module also housed the detection unit of an x-ray fluorescence spectrometer. It had a double shell capable of withstanding a pressure of 100 atm. A surface material receptacle was situated within the body, as well as a $^{238}Pu$ source with an activity of 50 mCurie, two $^{55}Fe$ sources with an activity of 125 mCurie each, four detectors (gas proportional counters) and, in addition, an electronic device for amplifying the signals and commutating the detectors. The detector signals were analyzed and stored by an amplitude analyzer. There were also four counters, three of which had a filling of 90% K + 10% CH, whereas one had a filling of 90% Xe + 10% $CH_4$. The first three counters were intended for the registry of x-radiation with an energy up to 6 keV and the last was for an energy from 4 to 15-20 keV.

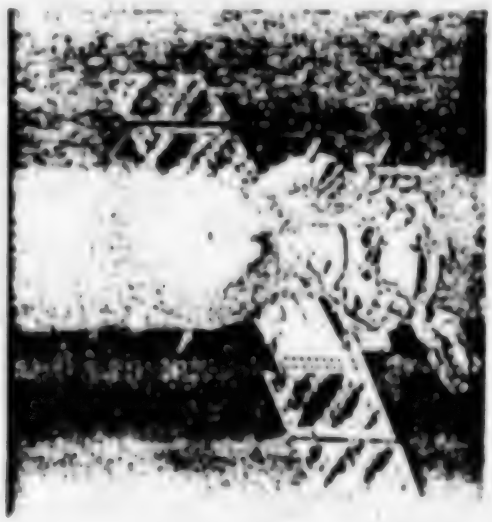
The operation of the x-ray fluorescence spectrometer on the Venusian surface proceeded in accordance with the stipulated program. The spectrometer was triggered at an altitude of 25 km above the Venusian surface and for a period of 35 minutes (up to the time that the descent module touched the planetary surface) made measurements of background spectra intended for spectrometer calibration.

This multichannel scintillation gamma spectrometer was used on the "Vega-1" and "Vega-2" au.omatic interplanetary stations for determining the content of uranium, thorium and potas:ium in Venusian rocks.

After landing a rock sample was taken by drilling, the gas sample surrounding this sample was eliminated and it was transported through the locking channel into the surface material receptacle. The atmospheric pressure surrounding the sample was reduced to 50 mm Hg at which the x-ray fluorescence spectrometer operated.



External appearance of landing module of "Vega-1" and "Vega-2"stations.



Representation of automatic interplanetary station of "Vega" series.

The first approximate estimate of composition of the rock obtained at the landing site of the "Vega-2" indicated that according to the terrestrial petrographic classification this composition can readily be identified with olivine gabbro-norite, a representative of a quite commonly occurring group of terrestrial gabbroids of normal alkalinity. Such rocks are present on the earth both amidst Precambrian stratified rock complexes and in Mesozoic ophiolitic complexes. The detected petrochemical characteristics may be evidence that the formation of this Venusian rock occurred during the differentiation of some initial melt containing not more than 1% water by mass. Under terrestrial conditions such melts are segregated from the mantle in the temperature range 1,200-1,400°C at a depth from 10 to 60 km.

With respect to the composition of rock at the "Venera-13" landing site, the classification indicates that this rock belongs to a group of very poorly differentiated melanocratic alkaline gabbroids. It is worth noting the low content of silicon oxide and the extremely high content of magnesium and potassium oxides. In the "Venera-8" landing region (3,000 km to the east of "Venera-13," but in a region of the same structural-morphological type of surface), the content of potassium oxide in the rocks, according to gamma spectrometry data, was approximately similar (~4%). This is evidence that in the cratered ancient hilly highlands of Venus melanocratic alkaline gabbroids of the phonolitic nephrite type in all probability are quite widespread.

The chemical composition of the rocks, determined by means of the "Venera-14" descent module, as well as the ratio of the petrogenic components, clearly indicate a similarity between Venusian rock and oceanic tholeiitic basalts on the earth of Mesozoic-Cenozoic age. However, the tholeiitic basalts on the earth were formed during outpourings of viscous magmas, whereas on Venus (probably as a result of the great gas saturation of the basaltic melts) there was an explosive character of the eruptions, leading to the formation of rocks of the sedimentary type.

## Mineral Composition of Rocks

Whereas we already have some idea concerning the chemical composition of rocks on the basis of experiments carried out on Venus, with respect to mineral composition there are still no experimental data. The difficulty in obtaining these data has stimulated many thermodynamic computations. It follows from these, in particular, that in the products of weathering of rocks of basic and acidic composition it is possible to expect primarily an accumulation of sulfur in the form of sulfides whose content may attain 10% by mass.

The geochemistry of iron and sulfur in surface rocks is evidently determined by a sulfide-sulfate solid-phase buffer (pyrite-anhydrite-magnetite). This buffer is responsible for a low partial pressure of oxygen in the surface layer of the troposphere. Depending on the hypsometric level of the surface (pressure change by several tens of atmospheres) there should be a change in the forms in which sulfur is present in minerals: in the high-mountain regions it is pyrite which is most stable, whereas in lowland regions it is anhydrite.

The limiting content of water vapor necessary for the stable existence of hydrated silicates (tremolite) at the surface is 300 ppm. This considerably exceeds the water vapor concentration in the surface atmosphere and therefore under modern conditions the hydration of rocks at the Venusian surface is improbable.

Principal Results

We will compare Venus with other bodies in the solar system in order to detect some features in the history of their formation and present-day structure which they have in common.

At present we have the greatest amount of information concerning the lunar surface and crust. Studies of the moon have made it possible to detect two types of early crust on its surface: feldspathic and basaltic. The initial all-planetary "continental" crust of feldspathic composition was probably formed in the last stage of lunar accretion and has a clearly magmatic origin. The basaltic sectors of the crust (relatively smooth lowlands) were formed in a later period as a result of surface emergence of deep melts. A similar picture is also observed on Mars, although the feldspathic and basaltic regions are less clearly expressed since great wind speeds (Martian storms) give rise to the transport of an enormous mass of surface material which levels the relief and averages out the composition of the rock lying on the surface.

The impact-explosion process, developing against a background of gravitational compression, evidently is typical for all the large bodies of the solar system. The role of this process in the formation of planetary bodies, and especially the earth, was previously underevaluated.

The second important result of study of Venus, Mars and the Moon was establishing the fact of appearance of early basaltic melts (3.6-3.8 billion years ago) synchronous with the process on the earth; these are obviously superposed on an earlier forming "continental" crust covering it in surface depressions.

In a comparison of the Moon, Mars, Venus and the Earth we note the circumstance that the preservation of the surface of the primordial "continental" crust is lessened regularly with an increase in the size of the planetary bodies and the degree of its coverage by basalts accordingly increases. And it appears that the earth's original crust also could not be preserved after having been virtually completely covered with basalts 3.8-3.0 billion years ago.

These circumstances raise a number of new and fundamental problems in the geological history of the earth. In particular, it is necessary to understand the absence of the original "continental" crust on the earth, that is, the absence of rocks more ancient than 3.8 billion years, to clarify the role of impact processes in the appearance of the most ancient continents and also to reexamine the soundness of interpretation of structure of the earth's

oceanic crust and the original composition of the earth's mantle. The solution of these and many other problems related to the history of formation and modern structure of solar system bodies is becoming the object of principal focus in comparative planetology.



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# ENCOUNTER OF 'VEGA-1', 'VEGA-2' SPACECRAFT WITH HALLEY'S COMET

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 8, Aug 86 (manuscript received 24 Apr 86) pp 581-592

[Article by R.Z. Sagdeyev, J. Blamont, A.A. Galeyev, V.M. Kovtunenko, V.I. Moroz, K. Szego, V.D. Shapiro, and V.I. Shevchenko]

[Abstract] The encounter of the "Vega-1" and "Vega-2" probes with Halley's comet made it possible to estimate the size of the cometary nucleus, its configuration and reflectivity and to observe complex processes within the gas and dust comas. Nine countries participated in organization of the "Vega" project. Figure 1 is a diagram of one of the identical "Vega" vehicles showing instrument placement. Another diagram shows the direction of the spacecraft velocity vector relative to the comet. The weight of each probe is 2.5 tons. Figure 2 shows the flight trajectory of the "Vega" probes. Most measurement data were transmitted to the earth at real time at a rate of 65536 bit/s. The 14 instruments carried aboard the two "Vega" vehicles are listed in Table 2. The Flight Control Center was at Yevpatoriya in the Crimea. Data were received by antennas at Yevpatoriya and near Moscow. About 1,500 cometary images were obtained as a result of the television experiment, about 70 from distances between 8,000 and 50,000 km. The nucleus is an elongated body measuring about 14±1 x 7.5±1 x 7.5±1 km. The period of rotation (53±2 hours) was determined by comparing images obtained from the two "Vega" probes. The nucleus unquestionably has a double or multiple structure. One of the important results of the IR experiment was discovery of strong IR radiation. The temperature of the nucleus was from 300 to 400K, much greater than the temperatures predicted by "ice" models of the nucleus. Important data were obtained on the mass distribution of dust particles and interaction with the solar wind, as well as on the structure of the cometary bow shock. Figures 2; references 31: 16 Russian, 15 Western.

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# TELEVISION EXPERIMENT FOR OBSERVING HALLEY'S COMET FROM 'VEGA' SPACECRAFT

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 8, Aug 86 (manuscript received 24 Apr 86) pp 593-603

[Article by R.Z. Sagdeyev, G.A. Avanesov, P. Cruvellier, L. Szabo, K. Szego, A.A. Abergel, A. Balasz, I.V. Barinov, J.-L. Bertaux, J. Blamont, B.I. Valnicek, L. Varholmi, M. Detaille, E. Demarelis, G.N. Dulnev, M. Zsenei, B.S. Zhukov, Yu.K. Zayko, S.I. Zatsepin, Ya.L. Ziman, V.I. Kostenko, V.A. Krasikov, Z. Nyitrai, T. Nguyen-Trong, I. Reny, P. Ruzsnyak, F. Szabo, S. Szalai, B. Smith, K.G. Sukhanov, V.I. Tarnopolskiy, I. Toth, G.I. Tsukanova and V.A. Shamis, Space Research Institute, USSR Academy of Sciences, Moscow; Space Astronomy Laboratory, National Scientific Research Center, Marseilles, France; Aeronomy, Verrieres-le-Buisson, France; Astronomical Institute, Czechoslovakian Academy of Sciences, Prague, Czechoslovakia; Precise Mechanics and Optics Institute, Leningrad; Central Physical Research Institute, Budapest, Hungary]

[Abstract] In the "Vega" project the principal objectives of the television survey were to ascertain if the cometary nucleus was a consolidated body or whether it consisted of individual bodies; to determine the parameters of rotation; to detect the composition and texture of the nucleus surface; to clarify the nature of emission of matter from the nucleus surface; to pinpoint active zones; and to study the morphostructure and dynamics of the coma around the nucleus. The greatest emphasis was on determination of the configuration and volume of the nucleus. A four-channel television system was used which had two cameras with focal lengths 120 and 150 μm. It transmitted to Earth images with a number of different-size formats. The narrow-angle camera could make a survey in six different spectral intervals of the visible and near-IR spectral regions, whereas the wide-angle camera functioned in only a single interval. The television system was mounted on a rotating platform which made it possible to change the position of the line of sight for the cameras by ±110° in the plane of the ecliptic and ±60° along the normal to it. The TV surveys of Halley's comet were initiated on the "Vega-1" and "Vega-2" on 4 March and 7 March 1986, respectively, at a distance of $14 \cdot 10^6$ km, with subsequent surveys being made daily until 11 March 1986. A total of about 70 images were obtained from distances less than $50 \cdot 10^3$ km in different aspects. A comparison of the images received from the two spacecraft made it possible to reconstruct the three-dimensional figure of the comet and to estimate its size. The nucleus is potato-shaped and measures 14±2 x 7.5±1.5 x 7.5±1.5 km. The rotation appears to be direct, with a period of rotation of the nucleus of 54±3 hours (should the rotation be retrograde, the period would be 44±3 hours). Figures 9; references: 8 Western.

UDC 523.64

# FIRST RESULTS OF MEASUREMENTS OF ELEMENTAL COMPOSITION OF DUST PARTICLES OF HALLEY'S COMET BY PUMA INSTRUMENTS IN 'VEGA' PROJECT

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 8, Aug 86 (manuscript received 24 Apr 86) pp 604-610

[Article by R.Z. Sagdeyev, I. Kissel, J.-L. Bertaux, V.N. Angarov, J.E. Blamont, K. Buchler, Ye.N. Evlanov, B.V. Zubkov, G.G. Managadze, S.N. Podkolzin, S.R. Tabaldyyev, M.N. Fomenkova, N. Horner, V.N. Khromov and V.D. Shapiro, Space Research Institute, USSR Academy of Sciences, Moscow; Nuclear Physics Institute, M. Planck Society, West Germany; Aeronomy Service, France]

[Abstract] The PUMA instrument carried aboard the "Vega" space probes includes a time-of-flight mass spectrometer in which the elemental composition of cometary dust is determined by analysis of the ion composition of the plasma forming during high-velocity impact ($\approx$ 80 km/s) of a dust particle on a target. The instrument is self-adjusting to changing conditions in the cometary dust cloud. Primary processing of data precedes transmission through a telemetric channel. The target area was $\approx 5$ cm$^2$, ensuring capability for registry of an adequate number of impacts of large dust particles. The Brownlee model of cometary dust was used (dust particles have a porous structure and their chemical composition is close to type-C1 carbon chondrites). Whereas the PUMA-1 operated faultlessly, the PUMA-2 was not fully operative until shortly before maximum approach to the comet. It was possible to discriminate three types of mass spectra. In the first type peaks predominated at masses 12, 16, 23, 24, 28, 40 and 56 amu, indicating presence of C, O, Na, Mg, Si, Ca and Fe. These particles may be very close in composition to carbon chondrites. The second type differs from the first due to the peaks for 1, 12, 14 and 32 amu, indicating a high dust particle content of carbon and nitrogen. In the third type the peaks 1, 12 and 16 amu predominate; there is little or no contribution from 24, 28 or higher masses. These "ice" particles may have an insignificant mineral nucleus or none at all. About 80 percent of the spectra belong to the latter two types. Adoption of the model of a type-C1 carbon chondrite is difficult due to the high C and N content. Figures 1; references 9: 3 Russian, 6 Western.

UDC 523.64

# INFRARED SOUNDING OF HALLEY'S COMET: PRELIMINARY RESULTS OF INFRARED SPECTROMETER EXPERIMENT ON 'VEGA' MISSION

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 8, Aug 86 (manuscript received 24 Apr 86) pp 611-615

[Article by M. Combes, V.I. Moroz, J.F. Crifo, J.M. Lamarre, J. Charra, N.F. Sanko, A. Soufflot, J.P. Bibring, S. Gazes, N. Coron, J. Crovisier, C. Emerich, T. Enkrenaz, R. Gispert, A.V. Grigoryev, Yu.V. Nikolskiy, G. Guyot, V.A. Krasnopolskiy and F. Rocard, Meudon Observatory, France; Space Research Institute, USSR Academy of Sciences, Moscow; Stellar and Planetary Physics Laboratory, National Scientific Research Center, Verrieres-le-Buisson, France; Rene Bern Laboratory, Orsay, France]

[Abstract] The IKS IR spectrometer carried aboard the "Vega" probes was for registry of the IR emission spectrum of the inner coma of Halley's comet in the ranges 2.5 and 6-12 μm (in the so-called spectrometric channels) and measuring temperature in the neighborhood of its nucleus and size of the nucleus in two perpendicular directions (in the so-called image channel). The IR detectors were cooled to 80K by a cryogenic system. The instrument was designed, fabricated and calibrated in France. It was flight tested jointly by French and Soviet specialists, who also jointly processed and interpreted the data. The experiment was successful on the "Vega-1," with measurements in the image channel ending several minutes after passage of the point of closest convergence. No experiment was possible on "Vega-2" due to failure of the cryogenic system. The spectrum in the region 2.5-5 μm contained narrow emission bands at 2.7 and 4.5 μm which can be identified with the fundamental rotational-vibrational bands $\nu_3$ of $H_2O$ and $CO_2$. An absorption band of $H_2O$ may be present near 3 μm. In the region 6-12 μm there are two broad emissions--strong from 6.5 to 9 μm and weaker from 9 to 11 μm. The strong emission can be identified with silicates and the weak emission with the C-C bond. The emitting region of the nucleus measures several kilometers and the temperature is significantly greater than 300K. In the inner parts of the coma the dust component possibly contains hydrocarbons and carbonaceous materials. Figures 4; references 6: 1 Russian, 5 Western.

UDC 523.64

# THREE-CHANNEL SPECTROMETER EXPERIMENT ON 'VEGA-2': SOME RESULTS OF SPECTROSCOPIC STUDY OF HALLEY'S COMET

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 8, Aug 86 (manuscript received 24 Apr 86) pp 616-623

[Article by V.A. Krasnopolskiy, G. Morels, M. Gogoshev, V.I. Moroz, A.A. Krysko, V.V. Barke, V.S. Zhegulev, N.F. Sanko, V.S. Troshin, G.V. Tomashova, A.Yu. Tkachuk, V.A. Parshev, B.S. Novikov, I.I. Sulakov, O.S. Fedorov, J. Clairmidi, M. Vencent, B. Mougin, J.P. Parisot, J.M. Zucconi, J.P. Lepage, J. Runavot, J.-L. Bertaux, J.E. Blamont, M. Festou, M. Herse, Ts. Gogosheva, S. Sargoychev, K. Palazov, A. Georgiyev, I. Nedkov, K. Kanev, B. Valnicek and V. Vanicek, Space Research Institute, USSR Academy of Sciences, Moscow; Central Space Research Laboratory, Stara Zagora, Bulgaria; Besancon University, France; Astronomical Institute, Ondrejov, Czechoslovakia]

[Abstract] The TKS three-channel spectrometer carried aboard the "Vega-2" spacecraft is a combination of three spectrometers using common systems for power supply, heat regulation, collection and processing of commands, a telescope and scanning device. The channel ranges are 0.95-1.9 μm, 275-715 nm and 120-290 nm. Spatial scanning is by small rotations of the secondary telescope mirror. Scanning is in two coordinates with formation of a frame measuring 2 x 1.5°. On the "Vega-2" no spectra were obtained in the range 120-290 nm due to a malfunction; no spectra were obtained on the "Vega-1" for the same reason. The spectra in the region 0.95-1.9 μm (obtained at a distance of 300 km from the nucleus) revealed the $H_2O$ band 1.38 μm and an OH band excited in the photodissociation of primary molecules, their intensity corresponding to a production rate $Q_{H_2O} = 4 \cdot 10^{29} s^{-1}$ and $Q_{OH} = 1.7 \cdot 10^{30} s^{-1}$. The density of dust particles is 0.35 $g/cm^3$, characteristic for "flaky" particles of interplanetary dust. In the region 275-715 nm in the spectra obtained at a distance of 4,000 km from the nucleus, emissions of 10 components are noted. The difference in $H_2O$ and OH production rates is possibly attributable to saturation effects, but the presence of other parent molecules for OH other than $H_2O$ is not precluded. Since ionic emissions in the comet are more conspicuous near the tail, they are not discussed. Figures 4; references 14: 2 Russian, 12 Western.

UDC 523.64+523.44

# STUDY OF DUST IN HALLEY'S COMET FROM 'VEGA' STATIONS: PRELIMINARY RESULTS OF SP-2 EXPERIMENT

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 8, Aug 86 (manuscript received 16 Apr 86) pp 624-630

[Article by Ye.P. Mazets, R.L. Aptekar, S.V. Golenetskiy, Yu A. Guryan, A.V. Dyachkov, V.N. Ilinskiy, V.N. Panov, G.G. Petrov, A.V. Savvin, R.Z. Sagdeyev, I.A. Sokolov, N.G. Khavenson, V.D. Shapiro and V.I. Shevchenko, Physical Technical Institute imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad; Space Research Institute, USSR Academy of Sciences, Moscow]

[Abstract] The general picture of dust distribution in Halley's comet during the time of flyby of the "Vega-1" and "Vega-2" spacecraft is described. The main objective of the SP-2 particle detector experiment was a determination of the spatial distribution of cometary dust particles and their mass distribution in a broad range from $\sim 10^{-16}$ to $10^{-6}$ g. The successive flyby of the two craft made it possible to evaluate changes of these characteristics with time. Essentially the same methods were used as in investigating cosmic dust in the earth's neighborhood from "Cosmos" satellites during the period 1966-1972. Two types of particle impact detectors were used: acoustic detector and impact plasma detector. The SP-2 detectors indicated entry of the "Vega-1" vehicle into the dust coma of Halley's comet at a distance $\approx 280{,}000$ km from its nucleus. There is no sharply defined boundary of the dust envelope. A steady increase in the rate of collisions begins at $\approx 1.8\text{-}2.0 \cdot 10^5$ km from the nucleus. The steepness of the curve of mass distribution of particles in the central region of the dust coma (where most of the dust is concentrated) gradually increases with transition from fine to larger particles. Within the dust coma the spatial distribution of dust is characterized by a complex structure. Figures 4; references 6: 2 Russian, 4 Western.

UDC 523.5

# DUST COMA STRUCTURE OF HALLEY'S COMET (SP-1 DETECTOR ON 'VEGA' SPACECRAFT)

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 8, Aug 86 (manuscript received 22 Apr 86) pp 631-638

[Article by O.L. Vaysberg, V.N. Smirnov, L.S. Gorn, M.V. Iovlev, M.A. Balikhin, Z. Zbyszynski, S.I. Klimov, Z. Kravczyk, S.P. Savin, V. Shapiro and V.I. Shevchenko, Space Research Institute, USSR Academy of Sciences, Moscow]

[Abstract] The SP-1 impact plasma detector carried on the "Vega" spacecraft measured the mass spectrum of dust in the range of small masses and the structure of the dust coma. The operating principle is based on the measurement of charges in the expanding plasma cloud which forms with the high-velocity impact of a dust particle against a target. The SP-1 has two independent detectors and consists of a gold target and a system of sensors. It was found that the boundary of the dust coma is at a distance $\approx$ 42,000 km at the subsolar point. At a greater distance, beyond the boundary, there were weaker dust particle fluxes. The mass spectrum continues to increase in the range of masses $10^{-15}$ to $10^{-16}$ g. There is a systematic impoverishment of the mass spectrum in the range $\sim 10^{-14}$ g with distance from the nucleus, possibly a manifestation of Mie resonances. Large-scale jets or clouds are observed and differentiation of particles of different masses is possible. The greatest dust activity and nonuniformity in dust distribution are registered in a cone with an aperture angle 70-80° oriented toward the sun. There was a narrow jet in which the spatial dispersion of particles made it possible to estimate the period and direction of rotation of the nucleus, indicate the possible location of the source and compare the findings with theoretical computations. Figures 3; references 13: 3 Russian, 10 Western.

UDC 523.64

# DUST COMA OF HALLEY'S COMET: MEASUREMENTS USING DUSMA DUST COUNTER AND MASS ANALYZER

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 8, Aug 86 (manuscript received 29 Apr 86) pp 639-646

[Article by J.A. Simpson, R.Z. Sagdeyev, A.J. Tuzzolino, M.A. Perkins, L.V. Ksanfomaliti, D. Rabinovitz, G.A. Lentz, V.V. Afonin, E. Keppler, O.F. Ganpantserova, N.V. Goroshkova, A.V. Zharkov, Yu.S. Kosorukov, B.S. Novikov, Ye.V. Petrova, L. Szabo, G. Umlauft, D.A. Usikov, N.G. Chebotarev and J. Ero, Enrico Fermi Institute, University of Chicago, Chicago, Illinois, United States; Space Research Institute, USSR Academy of Sciences, Moscow; Central Physical Research Institute, Hungarian Academy of Sciences, Budapest, Hungary; Max Planck Aeronomy Institute, Lindau, West Germany]

[Abstract] The dust emission from the nucleus of Halley's comet was measured on the "Vega-1" and "Vega-2" spacecraft using the DUSMA dust mass analyzer. The detector had an area of 75 $cm^2$ which was oriented almost perpendicularly to the velocity vector of the craft relative to the dust particles. The instrument was designed, built and tested at the University of Chicago. The measurements for the first time made it possible to ascertain the spatial and temporal mass distribution and fluxes of dust particles emanating from the cometary nucleus. Important information was obtained for understanding the physical processes of dust emission from the nucleus, its propagation and formation of the coma and formation of dust jets. The work was based on a new principle for the registry of cometary dust particles developed by Perkins, et al. and Simpson, et al. The instrument has a time resolution ~4 μs in a broad range of dust masses and fluxes. It was found that the dust coma, both in a quiescent state and when there were considerable emissions, exhibits the presence of large brief surges which in some cases have a quasiperiodic structure. The integral mass spectra reveal an increase in the intensity of fluxes with a decrease in the measured masses, contradicting some theoretical models. The flux levels lie approximately in the same region earlier detected by surface observations. Observations indicate that the coma is exceedingly dynamic in both time and space. Figures 4; references: 7 Russian.

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# OBSERVATION OF MAGNETIC FIELD IN COMA OF HALLEY'S COMET

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 8, Aug 86 (manuscript received 22 Apr 86) pp 647-652

[Article by W. Riedler, K. Schwingenschuh, Ye.G. Yeroshenko, V.A. Styazhkin and C.T. Russell, Space Research Institute, USSR Academy of Sciences, Graz, Austria; Terrestrial Magnetism, Ionosphere and Radio Wave Propagation Institute, USSR Academy of Sciences, Moscow; Geophysics and Planetary Physics Institute, University of California, Los Angeles, United States]

[Abstract] Since the "Vega" spacecraft were to pass within 8,000-10,000 km of the nucleus of Halley's comet, an experiment for measuring the magnetic field was organized for determining the characteristic scales of the zone of interaction between the comet and the solar wind, detecting the boundaries of different regions within the coma and ascertaining the degree of strengthening of the magnetic field at the magnetic barrier. The "Vega" probes carried Austrian-produced four-component ferrosonde magnetometers. The high-speed magnetometer interrogation mode on "Vega-1" was activated on 6 March 1986 when it was already within the bow shock, whose boundary was not readily detectable, although its position could be ascertained as $\sim 1 \cdot 10^6$ km from the cometary nucleus upon entry and $\sim 450 \cdot 10^3$ km upon emergence. The two spacecraft intersected the diffuse contact surface or cometopause at a distance $(50\text{-}20) \cdot 10^3$ km from the nucleus. The strengthened magnetic field 75-80 nTl measured within the cometopause is indicative of penetration of the solar wind into the outer cometary ionosphere and the rotation of the field vector within the ionosphere may be the result of observation of the preceding interplanetary field which still persisted in the cometary ionosphere. Figures 3; references 11: 4 Russian, 7 Western.

UDC 523.5

# PRELIMINARY RESULTS OBTAINED USING 'ING' INSTRUMENT FOR MEASURING NEUTRAL GAS DURING 'VEGA-1' FLYBY OF HALLEY'S COMET ON 6 MARCH 1986

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 8, Aug 86 (manuscript received 22 Apr 86) pp 653-656

[Article by E. Keppler, V.V. Afonin, C. Curtis, A.V. Dyachkov, J. Ero, C. Fan, K.C. Hsieh, D.M. Hunten, W.-H. Ip, A. Richter, A. Somogyi and G. Umlauft, Aeronomy Institute, M. Planck Society, Lindau/Harz, West Germany; Physics Department, University of Arizona, Tucson, United States; Central Physical Research Institute, Hungarian Academy of Sciences, Budapest, Hungary; Space Research Institute, USSR Academy of Sciences, Moscow; Planetary Research Department, University of Arizona, Tucson, United States]

[Abstract] The field ionization principle is used in the ING neutral gas measuring instrument carried aboard the "Vega" spacecraft. The system is capable of registering not only cometary particles, but also those formed near the spacecraft. The influence of the background of locally forming gas was lessened by placing the instrument in the upper part of the spacecraft. The ING is oriented in the direction of the comet at an angle 52° from the spacecraft-sun direction and at an angle 7° to the plane of the ecliptic; the field of view is 1 x 2°. The counting rate began to exceed the background beginning with ~ 60,000 km from the comet. The collected data made it possible to analyze the relative changes in the density of neutral gas. Since the ING time resolution is 2 s, formations with a width of more than 150 km were reliably measured. There is a fine structure which consisted of bursts with a duration up to 10 s, corresponding to formations with an increased density of particles measuring about 500-700 km. Figures 2.

UDC 523.64

# FIRST DIRECT MEASUREMENTS OF ENERGETIC PARTICLES NEAR HALLEY'S CLIMATE

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 9, Sep 86 (manuscript received 22 Apr 86) pp 659-665

[Article by A.J. Somogyi, K.I. Gringauz, K. Szegö, L. Szabo, Gy. Kozma, A.P. Remizov, J. Ero, N. Klimenko, I.T. Szucs, M.I. Verigin, J. Windberg, T. Cravens, A.V. Dyachkov, G. Erdos, M. Farago, T. Gombosi, K. Kecskemety, E. Keppler, T. Kovacs, A. Kondor, Yu.I. Logachev, L. Lohonyai, R. Marsden, R. Redl, A. Richter, V.G. Stolpovskiy, J. Szabo, I. Szentpetery, A. Szepesvary, M. Tatrallyay, A. Varga, K. Wenzel, G.A. Vladimirova and A. Zarandy]

[Abstract] The "Tyunde-M" instrument, carried aboard the "Vega-1" spacecraft, was for the registry of intense fluxes of energetic ions ($\gtrsim 40$ keV) in the neighborhood of Halley's comet, beginning at a distance $\approx 10^7$ km from the point of maximum approach. Three regions with different characteristics of ions were discovered. The first region was beyond the point of intersection of the bow shock during approach to and withdrawal from the comet at a distance $\approx 10^6$ km from the nucleus. Energetic ions were registered as far as $\approx 10^7$ km from the nucleus. The characteristic scale of this region is several million kilometers. The second region was characterized by the strongest fluxes. It included the bow shock and a large part of the transition region. The characteristic scale of this region was hundreds of thousands of kilometers. The third, inner zone, was characterized by a reduced flux level and intensity bursts against this background. This region of impoverishment with energetic particles apparently corresponds to a zone of plasma of cometary origin. The characteristic scale of this region is several tens of thousands of kilometers. In addition, in the region of closest approach there were several intensity bursts with a scale of several thousand kilometers. It is concluded that the behavior of these energetic ions is phenomenologically related to interaction between the solar wind and Halley's comet. Figures 3; references 14: 4 Russian, 10 Western.

UDC 523.64

# FIRST DIRECT MEASUREMENTS OF PLASMA AND NEUTRAL GAS NEAR HALLEY'S COMET: INITIAL RESULTS FROM 'VEGA' SPACECRAFT

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 9, Sep 86 (manuscript received 22 Apr 86) pp 666-674

[Article by K.I. Gringauz, T.I. Gombosi, A.P. Remizov, I. Apathy, T. Szemerey, M.I. Verigin, L.I. Denshchikova, A.V. Dyachkov, E. Keppler, I.N. Klimenko, A. Richter, A. Somogyi, K. Szego, S. Szendro, M. Tatrallyay, A. Varga and G.A. Vladimirova, Space Research Institute, USSR Academy of Sciences; Central Physical Research Institute, Hungarian Academy of Sciences, Budapest, Hungary; Aeronomy Institute, M. Planck Society, Katlenburg, West Germany]

[Abstract] During the "Vega-1" and "Vega-2" flyby of Halley's comet direct measurements of plasma formations were made. The objectives included a study of change in the parameters and distribution of plasma as a function of distance to the comet, study of the position and structure of the bow shock near the comet, determination of change in the chemical composition of plasma during approach to the comet and measurement of the distribution of neutral gas along the station trajectory. The PLAZMAG-1 instrument package, which included six different sensors, was intended for solving these problems. Two spherical electrostatic analyzers were used for measuring the energy spectra of ions in the direction of the spacecraft-comet relative velocity vector and in the direction of the sun. [AC--analyzer of cometary ions, AS--analyzer oriented in the direction to the sun.] A cylindrical electrostatic electron analyzer with an angular aperture 7 x 7° was oriented perpendicular to the plane of the ecliptic for measurements in 30 energy intervals in the energy range 3-10,000 eV. The energy spectra of electrons and ions were measured each second for about 4 hours, beginning about 3 hours before maximum approach to the nucleus. There were two charged particle traps oriented on the sun for measuring fluxes of solar wind ions. A plasma impact detector was for measuring the flux of neutral particles. Figure 1 shows the main plasma formations observed during approach of the "Vega" spacecraft. Figure 2 gives the results of 2-minute averaging of the high-resolution spectra obtained with the AS analyzer on "Vega-1." Figure 3 presents the same data for "Vega-2." Figure 4 shows several successive 1-second spectra registered by the AC analyzer at a distance of 15,000 km from the nucleus. Figure 5 shows two typical spectra of electrons (in region of cometary plasma and 2 days later in the interplanetary medium). Figure 6 illustrates measurements of the concentration of neutral particles as a function of cometocentric distance. These materials show that the region affected by the comet is far more extensive than theoretical studies had indicated. It had been postulated that only the region within the "contact surface" is dynamically separated from the solar wind, which is far from the case. Figures 6; references 8: 1 Russian, 7 Western.

UDC 523.6

# TWO-FREQUENCY RADIO SOUNDING OF HALLEY'S COMET DURING FLYBY OF 'VEGA-1' AND 'VEGA-2' SPACECRAFT

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 9, Sep 86 (manuscript received 12 May 86) pp 675-682

[Article by N.A. Savich, V.I. Altunin, V.Ye. Andreyev, Yu.F. Basos, N.-Ye.Ye. Boguslavskaya, A.S. Vyshlov, A.L. Gavrik, O.N. Doroshchuk, M.M. Kruchkovich, V.I. Lyaskovskaya, Ye.P. Molotov, I.M. Morskoy, A.S. Nabatov, M.A. Ovsyannikova, V.V. Seleznev, K.G. Sukhanov and A.S. Sheverdyayev, Radio Engineering and Electronics Institute, USSR Academy of Sciences, Moscow]

[Abstract] The radio transmitters on the "Vega-1" and "Vega-2," radiating two coherent radio signals in the decimeter (≈ 32 cm) and centimeter (≈ 5 cm) ranges, were used in making radiophysical investigations of Halley's comet. As the stations entered the cometary medium the radio waves sounded increasingly deeper regions to the minimum distance to the nucleus; sounding continued as the stations withdrew from the nucleus. Coherent reception of both signals was accomplished at the Deep Space Communication Center. Information was obtained on variation of the amplitudes, frequencies and reduced phase difference of the two coherent signals. Due to the geometry of the flyby it was only possible to carry out soundings of the head. In both cases soundings began about 32 minutes before passage through the pericenter and ended approximately 1 hour thereafter. The soundings demonstrated the existence of a considerably more extensive plasma envelope than anticipated. The time of appearance of a plasma effect corresponded to distances 100,000-60,000 km from the nucleus. The increase in total electron concentration was greater by a factor of 5-10 than expected from models. The preliminary estimate of electron concentration in the immediate neighborhood of pericenter indicates possible concentrations of thousands of electrons per cubic centimeter, considerably exceeding the expected levels. Figures 4; references 5: 1 Russian, 4 Western.

UDC 523.64

# OBSERVATIONS OF ELECTRICAL FIELDS, PLASMA NEAR HALLEY'S COMET

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 9, Sep 86 (manuscript received 22 Apr 86) pp 683-687

[Article by R. Grard, C. Beghin, M. Mogilevskiy, Yu. Mikhaylov, O. Molchanov, A. Pedersen, J.-G. Trotignon and V. Formisano, Terrestrial Magnetism, Ionosphere and Radio Wave Propagation Institute, Troitsk, Moscow Oblast; Space Research Section, European Space Agency, Noordwijk, Holland; Space Physics and Chemistry Laboratory, Orleans, France]

[Abstract] The APV-V (analyzer of low-frequency plasma waves) instrument was designed for measuring electrical fields in the frequency range 0-300 KHz and for measuring plasma parameters using two Langmuir probes. Electrical fields were measured using a dipole antenna with an 11-m base. The spectra of signals registered with the antenna were analyzed using 16 filters in the frequency band 8 Hz-300 KHz and were transmitted telemetrically to the earth. The APV-V instrument on "Vega-1" during approach to the comet on 6 March operated normally until arriving at a point 28,600 km from the nucleus at which time instrument malfunction occurred. A study was made of the results for 5 filters (10, 100 Hz, 2, 15, 100 KHz) (Figure 1 shows change in intensity of the electrical field at different frequencies as a function of distance to the nucleus; Figure 2 illustrates the dynamics of electrical field spectra with approach to the nucleus; Figure 3 gives measurements of the electron concentration near the spacecraft). Only at a frequency ~100 Hz, at a distance 2.5 million kilometers from the nucleus, was there an increase in the radiation level and at a distance ~1 million kilometers, a sharp decrease. This is attributable to the fact that a broad spectrum of electrical field oscillations is generated near the bow shock situated at ~1 million kilometers from the nucleus. With approach to the nucleus, maxima appear in the radiation spectrum at frequencies 200-500 Hz, and then also at a frequency ~30 Hz. The centr[illegible] frequency of the second maximum changes from 200 Hz at a distance 120,000 km to ~450 Hz at a distance ~30,000 km. Disappearance of the maxima with approach to the nucleus may be related to the masking effect of increasing radiation caused by impacts of cometary dust. Figures 3; references 5: 3 Russian, 2 Western.

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# EXTREMELY LOW-FREQUENCY (ELF) PLASMA WAVES IN NEIGHBORHOOD OF HALLEY'S COMET

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 9, Sep 86 (manuscript received 22 Apr 86) pp 688-695

[Article by S. Klimov, S. Savin, Ya. Aleksevich, G. Avanesova, V. Balebanov, M. Balikhin, A. Galeyev, B. Gribov, M. Nozdrachev, V. Smirnov, A. Sokolov, O. Vaysberg, P. Oberc, Z. Krawczyk, S. Grzedzielski, J. Juchniewicz, K. Nowak, D. Orlowski, G. Parfianowicz, Z. Zbyszynski, Ja. Vojta and P. Triska, Space Research Institute, USSR Academy of Sciences, Moscow; Physicomechanical Institute, Ukrainian Academy of Sciences, Lvov; Space Research Center, Polish Academy of Sciences, Warsaw, Poland; Aviation Institute, Polish Academy of Sciences, Warsaw, Poland; Geophysics Institute, Czechoslovakian Academy of Sciences, Prague, Czechoslovakia]

[Abstract] In the APV-N experiment (analysis of low-frequency plasma waves) aboard the "Vega" spacecraft the objective was the measurement of extremely low-frequency waves ($10^{-2}$-$10^{-3}$ Hz) during approach to Halley's comet and withdrawal from it. The experiment involved use of a combined method for the measurement of plasma waves: simultaneous measurement of fluctuations of both the electrical field and the ion flux in ambient plasma. In the APV-N the measurement of fluctuations of the electrical field E was performed by a double Langmuir probe, whereas measurement of fluctuations of the ion component in the plasma flux P was accomplished by a Faraday cylinder. The APV-N operated aboard the spacecraft in two modes: slow telemetry, with measurement of spectra at 15 fixed frequencies, and fast telemetry, with measurement of the spectra at 12 fixed frequencies. During the approach to the comet plasma waves were observed which could be identified (for the "Vega-1") with a quasiperpendicular bow shock, or with a quasiparallel bow shock ("Vega-2"), situated at a distance of 1-1.3 million kilometers from the cometary nucleus. Beyond the bow shock there were characteristic plasma oscillations and also oscillations associated with interaction between dust and the sensors and the spacecraft as a whole. Plasma oscillations were also observed which were excited by anomalously fast ionization of the cometary atmosphere by suprathermal electrons, hypothetically due to development of the critical ionization rate phenomenon. Figures 3; references 13: 7 Russian, 6 Western.

UDC 523.64

# MODEL OF GAS COMA OF HALLEY'S COMET BASED ON ULTRAVIOLET OBSERVATIONS USING 'ASTRON' ASTROPHYSICAL STATION

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 9, Sep 86 (manuscript received 28 Apr 86) pp 696-706

[Article by A.A. Boyarchuk, V.P. Grinin, A.M. Zvereva, P.P. Petrov and A.I. Sheykhet, Crimean Astrophysical Observatory, USSR Academy of Sciences, Nauchnyy]

[Abstract] In December 1985 the ultraviolet telescope on the "Astron" astrophysical station was used in spectrophotometric observations of Halley's comet in the wavelength range 1500-3500 Å with a spectral resolution 28 Å and a spatial resolution 1'. The most detailed observations of the region near the cometary nucleus were made on 3, 13 and 23 December. Coma spectra were registered at different distances from the nucleus. In addition, photometric traces of the coma running through the nucleus in the direction of the cometary axis of symmetry were registered for the fixed wavelengths λ 3085 and λ 2190 Å in the molecular bands OH(0-0) and $CO^+$(0-0). By extrapolating the law of change in the rate of water sublimation $Q_{H_2O}$ $r^{-3}$ as far as perihelion and considering it to be identical before and after perihelion, it was possible to estimate roughly the total loss of mass in one transit of Halley's comet ($\Delta M$ = 300 million tons). The "Vega" and Giotto experiments revealed that the cometary nucleus has an elongated shape measuring 7 x 11 km. Assuming the mean density of the ice nucleus to be 1 g/cm$^3$, during one transit the radius of the cometary nucleus should decrease due to the evaporation of matter by approximately 10 cm. Halley's comet will cease to exist in approximately 300,000 years after having made about 4,000 transits around the sun. All these findings indicate that Halley's comet in no way differs from other large short-period comets. Figures 7; references 29: 5 Russian, 24 Western.

UDC 523.42

# GEOMORPHOLOGICAL DESCRIPTION OF SEDNA AND GUINEVRE PLAINS ON VENUS (PHOTOMAP SHEETS V-11, V-20, V-21)

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 20, No 3, Jul-Sep 86 (manuscript received 18 Apr 86) pp 163-176

[Article by A.A. Pronin, G.A. Burba, N.N. Bobina, Yu.S. Tyuflin, A.I. Sidorenko, S.A. Kadnichanskiy, M.V. Ostrovskiy, V.A. Kotelnikov, O.N. Rzhiga, G.M. Petrov, Yu.N. Aleksandrov, V.A. Shubin and N.V. Rodionova, Geochemistry and Analytical Chemistry Institute imeni V.I. Vernadskiy, USSR Academy of Sciences; Central Scientific Research Institute of Geodesy, Aerial Mapping and Cartography imeni F.N. Krasovskiy; Radio Engineering and Electronics Institute, USSR Academy of Sciences]

[Abstract] The geomorphology of the Venusian surface is described for that part of the planet covered by sheet V-11 and parts of sheets V-20 and V-21 of the photomap of Venus. The principal geomorphological formations in the studied area are the southern part of the Lakshmi plateau, the Sedna and Guinevre plains. Figures 1 and 2 are a photomap and a geomorphological map of this area. The three principal geomorphological regions are described in detail. Most of the investigated surface consists of smooth plains probably formed by flows of volcanic lavas. Based on the density of impact craters imposed on these areas the mean age of the plains is estimated at 1 billion years. "Recent" lava flows are present and these were formed 200 million years ago or less. The Sedna plain resembles some volcanic regions on Mars and on the Earth and differs from most lunar maria due to the presence of individual volcanic domes and their clusters. The formation of these domes is evidently attributable to the presence of volatile components in the lava. In locations throughout the studied area there are hilly plains of a more ancient age. However, the most ancient geological complex is Clotho Tessera. On the plains there are poorly expressed but extensive lineaments forming NW-SE and NE-SW systems. Figures 9; references: 6 Russian.

UDC 523.42

RELIEF, GEOLOGY OF NORTH POLAR REGION ON VENUS

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 20, No 3, Jul-Sep 86 (manuscript received 18 Apr 86) pp 177-196

[Article by R.O. Kuzmin, G.A. Burba, V.P. Shashkina, A.F. Bogomolov, N.V. Zherikhin, G.I. Skrypnik, L.V. Kudrin, M.Yu. Bergman, O.N. Rzhiga, A.I. Sidorenko, Yu.N. Aleksandrov, I.M. Bokshteyn and M.A. Kronrod, Geochemistry and Analytical Chemistry Institute imeni V.I. Vernadskiy, USSR Academy of Sciences; Moscow Power Institute; Radio Engineering and Electronics Institute, USSR Academy of Sciences; Information Transmission Problems Institute, USSR Academy of Sciences]

[Abstra. ] Surface features in the north polar region of Venus were studied and mapped using radar images obtained from the "Venera-15" and "Venera-16" space probes. Radar images of two types were used: those obtained with processing of the signal directly aboard the vehicle and those obtained by processing the signal by ground-based computers. Figure 1 is a hyposometric map of the north polar region with isohypses drawn each 0.5 or 1 km; Figure 2 is a map annotated with approved placenames; Figure 3 is a photomosaic of the region to the north of 70°N; other figures show images at a larger scale and profiles and diagrams of the region. The interpretability of relief with different radar survey azimuths is discussed and the principal types of terrain and individual structures are described. The north polar region is a major lowland, primarily plains with hill zones and individual annular structures. The high density of impact craters indicates that this surface is the most ancient part of the areas surveyed. The studied area is characterized by relative youth of the impact craters and absence of highly degraded craters so characteristic of the ancient continental crust of the Moon, Mercury and Mars. The presently observed relatively young population of craters suggests an appreciable lessening of reworking of the planetary surface during the last billion years. Figures 9; references 9: 7 Russian, 2 Western.

UDC 523.42

# WATER VAPOR CONTENT PROFILE IN VENUSIAN ATMOSPHERE (BASED ON RESULTS OF EXPERIMENTS ON 'VEGA-1' AND 'VEGA-2' SPACECRAFT)

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 20, No 3, Jul-Sep 86 (manuscript received 13 Feb 86) pp 197-201

[Article by Yu.A. Surkov, O.P. Shcheglov, M.L. Ryvkin, D.M. Sheynin and N.A. Davydov, Geochemistry and Analytical Chemistry Institute imeni V.I. ernadskiy, USSR Academy of Sciences]

[Abstract] The VM-4 moisture analyzer was carried on the "Vega-1" and "Vega-2" landers. This instrument has two types of sensors: thermoelectrolytic and coulimetric. The first type has a heated moisture sensor based on LiCl with its operating principle being based on the temperature dependence of the elasticity of water vapor over the surface of a saturated solution of salt. The range of measurement of absolute moisture content is 0.38-31.8 mm Hg, corresponding to a dew point from -30 to +30°C. However, in the initial descent segment (60-50 km) a coulimetric sensor was used because it was postulated that the water vapor content was less than the response of the thermoelectrolytic sensor. Figures 1 and 2 are diagrams of the two types of sensors. It was found that the relative content of water vapor in the upper troposphere exhibits strong spatial and temporal variations in part related to the existence of diurnal and latitudinal variations, whereas in the lower troposphere, beneath the clouds, the water content is almost constant (0.01% by volume). In the troposphere beneath the clouds the relative $H_2O$ content decreases to about 30 km, possibly evidence of an extensive mist beneath the clouds. The water vapor content in the cloud layer is an order of magnitude greater than in the troposphere beneath the clouds. Below 30 km, water vapor partial pressure is proportional to the change in total pressure, suggesting a well-mixed atmosphere. Figures 3; references 4: 3 Russian, 1 Western.

UDC 523.42

## LONG-WAVE SHEARING STRESSES IN VENUSIAN LITHOSPHERE, MANTLE

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 20, No 3, Jul-Sep 86 (manuscript received 7 Apr 86) pp 202-211

[Article by V.N. Zharkov, K.I. Marchenkov and V.M. Lyubimov, Earth Physics Institute imeni O.Yu. Shmidt, USSR Academy of Sciences]

[Abstract] A joint analysis of the topography and nonequilibrium part of the gravity field has yielded information on the distribution of shearing stresses in the Venusian lithosphere and mantle. This was possible by computation of the load factors for real models of the planet with allowance for the asthenosphere for anomalous density waves observed at different characteristic levels. Computations of the long-wave shearing stresses in the lithosphere and mantle for zonal harmonics with n = 2-8 were made, revealing that stresses in the Venusian lithosphere are equal to approximately 30 bar; in the lower mantle they can attain up to 45 bar; in the weakened upper mantle they are only a few bars. The low level of shearing stresses in the Venusian crust and mantle is interpreted as an indication that the interior is greatly heated. The results confirm the conclusion drawn earlier that Venus is aseismic. On Earth the thickness of the seismically active surface layer is about 15 km and the geothermal gradient is ~ 20-30 K/km. Therefore at the lower boundary of the seismically active zone on Earth the temperature is 300-450°C. The mean temperature of the Venusian surface is 460°C. By deduction it can therefore be concluded that Venus has no outer seismically active layer. Figures 2; references 11: 6 Russian, 5 Western.

UDC 523.4

## MODELING MULTILEVEL CLOUD COVER IN JOVIAN ATMOSPHERE

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 20, No 3, Jul-Sep 86 (manuscript received 24 Apr 84, after revision 3 Apr 86) pp 228-234

[Article by K.Yu. Ibragimov, G.A. Kiriyenko and A.A. Solodovnik, Astrophysical Institute, Kazakh Academy of Sciences]

[Abstract] Multilevel cloud formations in the Jovian atmosphere in the presence of several components capable of condensation were modeled. (The basis for this work was laid in an article by K.Yu. Ibragimov in ASTRON. ZHURN., Vol 60, No 5, pp 1016-1021, 1983.) The model is based on a system of heat and moisture transfer equations for the case of two condensing substances (ammonia and water vapor). Profiles of clouds consisting of upper ammonia and lower water cloud layers were obtained. Conclusions were drawn concerning the existence and evolution of multilayer clouds in the

Jovian atmosphere. It is demonstrated that in some cases a water cloud can exert a considerable influence on formation and development of the ammonia cloud. Details are given on the formation and evolution of water-ammonia cloud layers, their relative influence and the search for quantitative relationships between the parameters of clouds and the initial factors characterizing the state of the Jovian atmosphere. The most important parameters involved are the turbulent diffusion coefficient, velocity of vertical ascent and relative concentrations of water and ammonia vapors. Localized sectors with increased temperature are observed in parts of the spectrum near 5 μm. It is shown that the influence of water clouds on ammonia clouds is related to these temperature anomalies at 5 μm. A sector where there is a thick water cloud may be screened by a thin translucent ammonia cloud, resulting in an excess of 5 μm radiation in this region. On the other hand, in places where lower water clouds are weak the heat flow from them is small and the upper screening ammonia cloud is very great and accordingly holds back 5 μm radiation to a greater degree. Figures 3; references 8: 6 Russian, 2 Western.

UDC 522.73+523.89+528.721

## REGRESSION MODELING OF DISCREPANCIES IN SELENODETIC COORDINATE SYSTEMS

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 20, No 3, Jul-Sep 86 (manuscript received 24 Jul 85) pp 235-245

[Article by S.G. Valeyev and V.A. Nikonov, Kemerovo State University; State Astronomical Institute imeni P.K. Shternberg]

[Abstract] A high-priority objective in selenodesy is devising a Unified Selenodetic Coordinate System based on surface and space observations. Two approaches to solution of this problem are possible. The first would involve reduction of the selenodetic catalogues obtained using surface and space data to a common system. The second would be the preparation of a catalogue of selenodetic coordinates on the basis of a space photo survey alone or exclusively on the basis of surface data. Work on this problem has been in progress at the State Astronomical Institute for integrating all observations, both Soviet and American. The point of departure was earlier work by S.G. Valeyev in IZV. VUZov: GEODEZIYA I AEROFOTOSYEMKA, No 3, pp 38-46, 1981, and V.A. Nikonov, PROBLEMY ASTROMETRII, Moscow, Izd-vo MGU, pp 299-302, 1984. Computers confirm the possibility of using third-degree polynomial systems for describing the discrepancies in systems of selenodetic catalogues. Two methods can be used in this process. The use of approximating polynominals can be used in problems in which only a high transformation accuracy is required. On the other hand, a combined approach is proposed when it is necessary not only to ensure a high transformation accuracy, but also to obtain the parameters of a geometric transformation for a sipulated theory. In the latter case the mathematical model will contain a constant part linked to the geometry of the transformation and a variable approximating component

describing various systematic errors. Models were formulated which contain a number of terms 2-4 times less than the initial model and increasing the internal accuracy of the description on the average by 7-8%. References 16: 13 Russian, 3 Western.

5303/6091
CSO: 1866/21

## REGIONAL CENTER FOR WEATHER SATELLITE DATA OPENS IN TASHKENT

Moscow PRAVDA in Russian 7 Jan 87 p 6

[Article by V. Artemenko and Yu. Chernogayev, correspondents]

[Excerpt] A regional center for receiving and processing of data from satellites has been created in Tashkent. Meteorological information from "Meteor" satellites is processed and used widely for weather forecasting.

Photographs are received here four times a day, which makes it possible to keep track of the dynamic development of atmospheric processes. The pictures are sent to an analytical laboratory, where specialists overlay them with a meridian grid to prepare weather maps. Copies of the maps are sent to weather services in Afghanistan, India, Iraq, Iran, Pakistan, Sri Lanka--to 15 countries in all.

The Tashkent center receives information on the weather over an area from the Indian Ocean to the Arctic Circle, and from Central Europe to East Siberia. The zone served by the Tashkent center takes in massive mountain ranges of Asia where there are no weather stations. Therefore it is understandable how important the satellite information is for this area.

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# STUDY OF EARTH FROM SPACE AND STRENGTHENING OF ECONOMY

Moscow ZEMLYA I VSELENNAYA in Russian No 4, Jul-Aug 86 pp 16-25

[Article by Yu. P. Kiyenko, candidate of physical and mathematical sciences, general director, "Priroda" State Center]

[Text] Under modern conditions of development of the economy appropriate attention must be directed to mobilization of natural production forces and acceleration of their study. For this reason there has been an increase, in particular, of the role of methods for remote sensing of the earth from space. It is not by chance that the item of broad and efficient use of space vehicles and methods for study of the earth's surface and its deep layers was included in the text of the "Principal Directions in the Economic and Social Development of the USSR During the Years 1986-1990 and for the Period Up to 2000," which was ratified by the 27th CPSU Congress.

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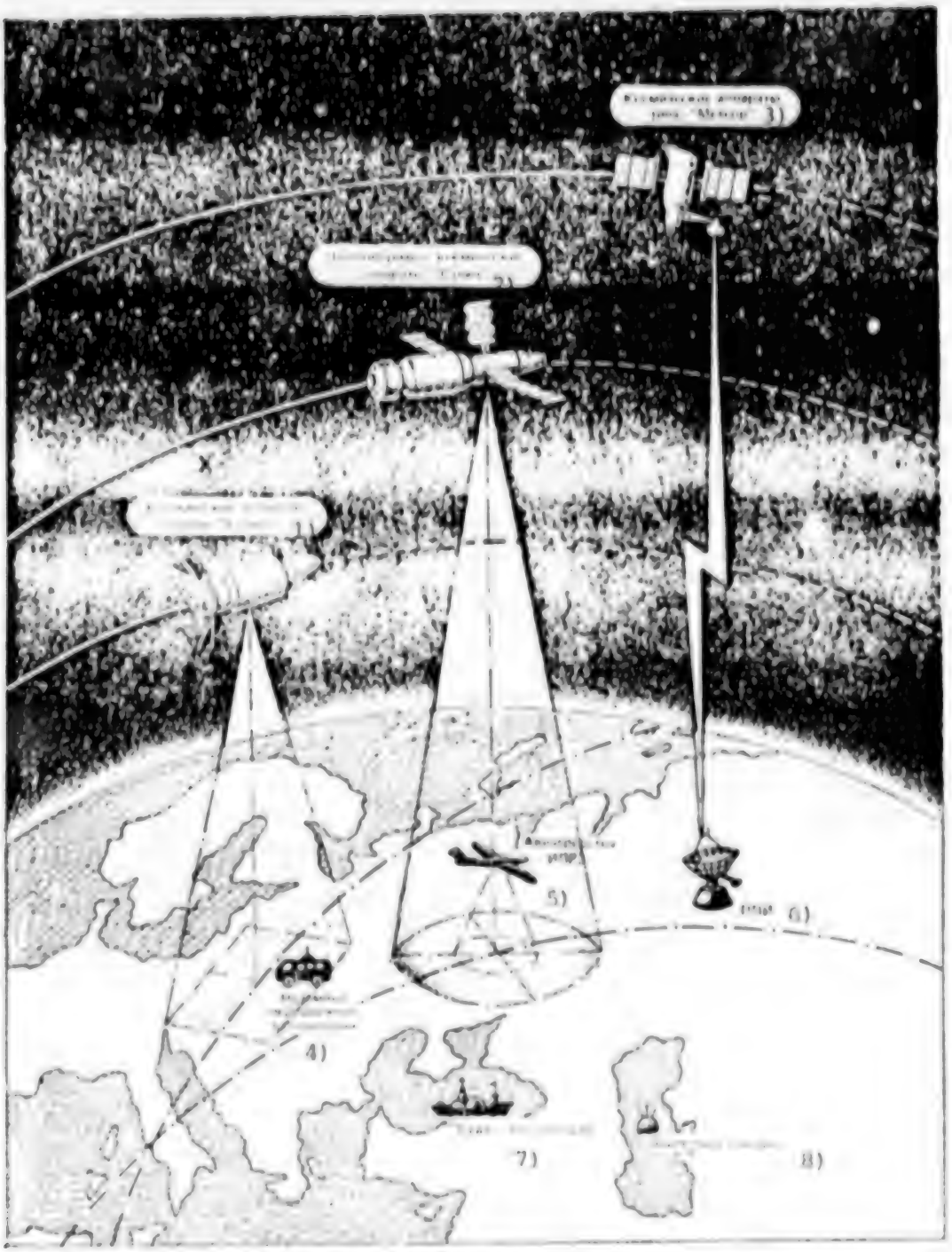
## Earth's Resources

Only a relatively short time has elapsed since the day of launching of the first artificial earth satellite. However, even now we have such results in the investigation of the earth from space which make it possible to speak of a new direction in study of our planet and its natural resources: study of the earth from space. Organically brought together in this new direction of fundamental and applied study of the earth are the most diverse fields of scientific knowledge and technology: almost all branches of the earth sciences, many applications of the physical-technical and mathematical scienc , radio engineering and electronics, precise mechanics, optics and comp ter science, cosmonautics and rocketry. Today in the USSR the study of the earth from space has risen to the level of a state scientific policy and is being s ccessfully developed, drawing upon the great scientific and industrial potential of the country, taking in ever-widening spheres of application and also increasing the efficiency of study and use of natural resources in the interests of development of the national economy and increase in the welfare of the Soviet people.

Our country, on a planned basis, is carrying out comprehensive programs for remote sensing of the earth from space and developing methods and techniques




Space system for study of natural resources.

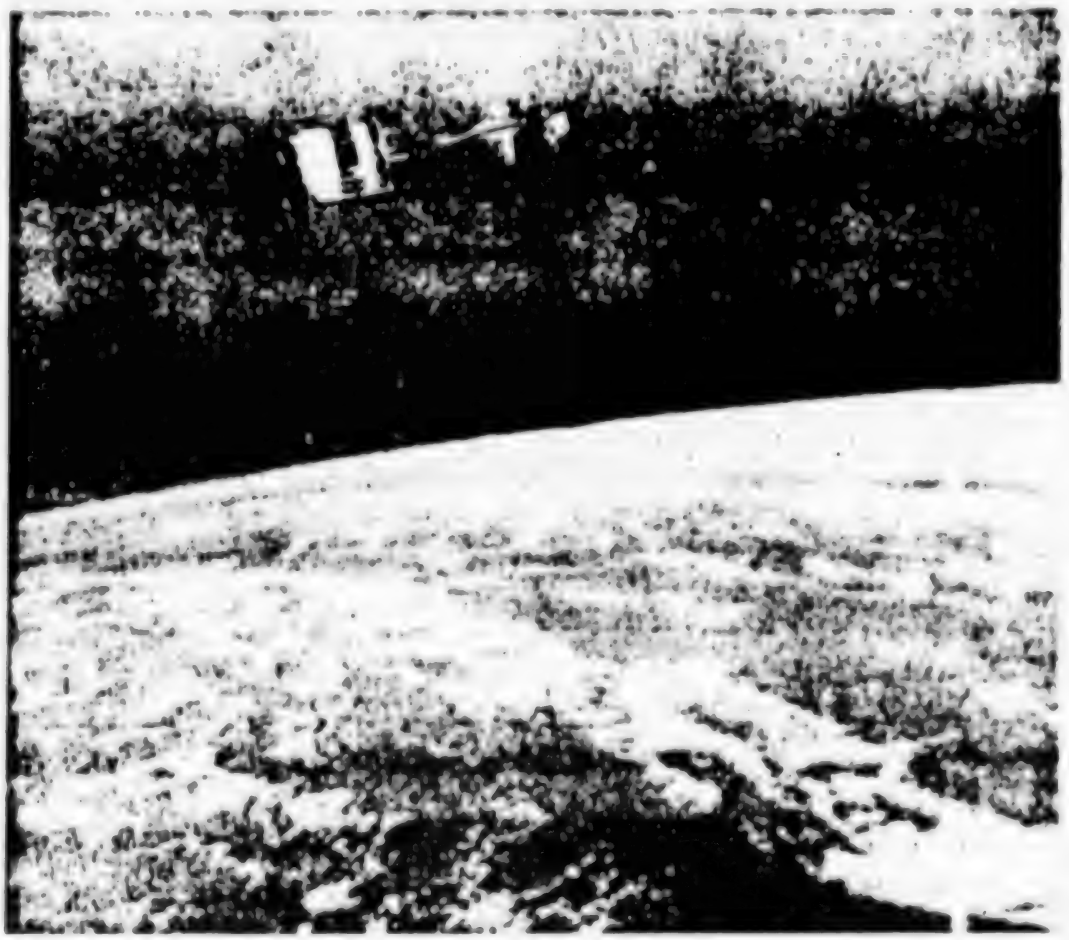
KEY:

1. Spacecraft of "Cosmos" series
2. "Salyut" manned spacecraft
3. "Meteor" spacecraft
4. Mobile surface laboratories
5. Aircraft for study of earth's natural resources
6. Receiver-transmitter installation
7. Ship laboratories
8. Buoy stations

KATE-140 camera carried by orbital stations of "Salyut" type and used in studying natural resources and mapping.

AN-30 aircraft laboratory. Used in sub-satellite experiments and aerial photographic surveying.

for the processing of space information and the use of remote sensing data for determining the natural potential of extensive expanses in different regions of the country. Considerable experience has been gained in the use of space information in different branches of the economy.



"Soyuz-19" space station in orbit.

It is fitting to raise the following question: how timely is the use of new methods for the study of natural resources? Only recently the traditional methods for the study of natural resources, which had taken form over the course of centuries, met the needs of the economy. The fact of the matter is that with an increase in population and the development of technology the most accessible resources are being exhausted and the search for new resources is becoming an increasingly more complex problem.

As is well known, the existence of mankind is unthinkable without the use of natural resources: solar energy, air, water, land, plant and mineral resources, the animal world and others. Some of them are being expended in the field of material production, such as agriculture and forestry, in industry, in the production of electrical and thermal energy, and others necessary in the nonproductive sphere, such as in the organization of comfortable living conditions and for sanitation purposes.

With respect to the exploitation and use of environmental resources they must be classified as virtually inexhaustible (solar energy, gravitational forces, thermal energy of the deep layers, wind energy) and exhaustible, which in turn can be classified as renewable and nonrenewable. Definite types of mineral raw material and fuel are among the latter. Renewable resources are renewed not only naturally, but also with man's participation.

The components of man's environment are being used more and more for the purposes of meeting the material and cultural needs of society. Whereas in ancient times man used only 19 chemical elements, and at the beginning of the 20th century 60, today use is being made of virtually all those encountered in nature.

Each day, throughout the world, approximately 100 billion tons of different products and materials are extracted from the environment. Each 15-20 years the volume of consumed fuel, ore and construction materials is doubling. The situation with fuel is particularly indicative. The global fuel resources are estimated at approximately 4 trillion tons of conventional fuel; 5-7 years ago the annual consumption was 10 billion tons. By the year 2000 the predicted annual consumption will attain 25-30 billion tons. In other words, the traditional energy resources will be able to ensure development of the world economy during the next century as well. However, these resources, like most others, are extremely nonuniformly distributed and in some regions have already been exhausted or are being exhausted. Accordingly, the costs of extraction of fuel raw material are increasing. An example of this is the exploration for and production of petroleum in the North Sea, more expensive than in the Middle East by a factor of 10-17. And although according to foreign predictions the Antarctic shelf contains petroleum reserves of 6 billion tons and gas reserves of 11.5 trillion cubic meters, one can imagine how much more expensive the production of fuel will be in that region.

The situation is similar with renewable resources. According to data published by the International Union for Preservation of the Environment, recently 40% of the tropical forests of our planet have been annihilated. Throughout the world 20 hectares of forest are being cut each minute.

The production of sea products is approaching the danger point. For example, the theoretical limit for the catching of fish is 200 million tons annually, but in the next 8-10 years the annual production of fish throughout the world will already exceed 120 million tons.

If it is taken into account that in the long run the consumption of resources by all mankind will be increased to the level of their consumption in the most developed countries of the world (there is no doubt but that such a trend exists), the total volume of their production will have to be increased by a factor of 3-4, and for some of the most important types of raw material and materials by a factor of 10-15.

The following must be emphasized: the theoretical estimates of potential reserves of raw material still do not indicate that the precise distribution of the future places of their production and exploitation is now known.

All this is convincing evidence of how important it is to improve the study of natural resources, to ensure their regional exploitation, reproduction of renewable types of natural wealth, environmental protection, economy of different types of raw material, materials and energy.

There is no doubt as to the timeliness of use of such methods and equipment for study of the environment which would ensure highly productive and routine search for natural wealth which is still not known and still not exploited for the dynamic development of the economy in the final quarter of the current century and thereafter.

The use of space technology in the study of the earth from space serves this purpose and will make it possible to bring about a real scientific and technical revolution in the study of natural resources.

From the General to the Particular

What is the essence of remote sensing of the earth from space and what are the advantages of space information over the data obtained by traditional methods? All objects in the environment reflect, generate or absorb electromagnetic waves of a definite spectral composition and intensity. These radiations can be registered by special detectors aboard a space vehicle and then characteristic indicators are used by specialists who interpret this material for the purpose of detecting definite features, processes or phenomena.

The peculiarities of space information are dictated by orbital flight conditions: a great altitude and velocity of motion of an artificial earth satellite.

Surveys from space ensure a virtually unlimited field of view -- from local to global, collection of data on enormous expanses in short time intervals and observation of any inaccessible features, such as high-mountain regions, islands in oceans and so forth.

Aral Sea. Islands, shallow waters, shorelines, zones of occurrence of unconsolidated sands, road network, individual populated places and the delta of the Amu Darya are clearly visible. The photograph makes it possible to analyze the dynamics of Aral Sea shoaling and the desertification of the adjacent territory.

The great coverage of the territory viewed from space makes it possible to study different regions on the principle "from the general to the particular." This is exceedingly important for the effective formulation of the research. Earlier, with expenditure of great amounts of time, individual, frequently point or linear observations were made which were accumulated, systematized, thought through, and only prolonged work made it possible to study large-dimensional features. On the basis of space surveys the researcher in most cases proceeds from the detection of general patterns to the discovery of specific objects. For example, in studying the geological structure of a territory it was earlier necessary to cover routes many kilometers in length and to integrate the results of work by individual field workers, parties and expeditions and only then was it possible to confirm the existence of faults in the earth's crust and the strike of different rocks... Having space photographs such problems are solved with a minimum amount of expensive field work,

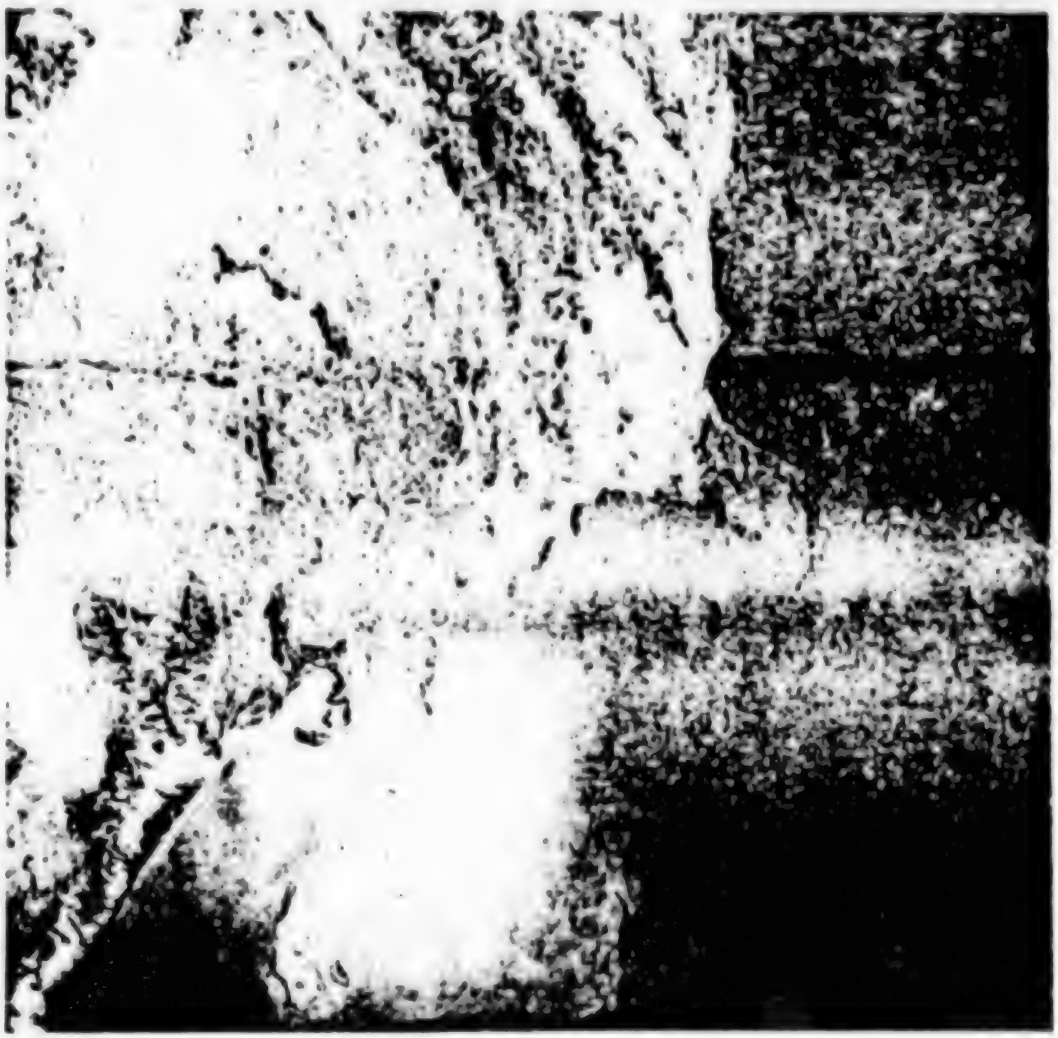
with a saving of time and equipment. As a result, there is an increase not only in the productivity of labor, but also an increase in the efficiency of research. It also must be noted that surveys from aboard a space vehicle, scaled to a unit of studied area, are several times cheaper than surveys from an aircraft.

Kara-Bogaz Gol gulf. The photograph makes it possible to interpret stages in change of shoreline ("Salyut-6," KATE-140).

The obvious advantages of space information have led to a legitimate conclusion: it is necessary to develop a special space system for the study of natural resources and the environment. An analysis of the needs of the national economy has demonstrated that such a system should be permanently in operation and multifunctional, ensuring the collection of multipurpose information for different branches, information intended for repeated use.

The developed system incorporates or uses the following elements as attractive features: automatic space vehicles of the "Cosmos" series; automatic space

vehicles of the "Meteor" type; manned orbital stations and ships; aircraft laboratories and helicopters; stationary and mobile land and sea vehicles for contact and close measurements; a network of land and sea control-measurement test ranges for the calibration of satellite- and aircraft-borne equipment for remote sensing and for the detection of interpretation criteria for natural features; surface points for the reception and interbranch processing of space information; a far-flung network of branch organizations using space information.



Apsheron Peninsula. Shallow waters, areas of agricultural production, forests and faults in the earth's crust are visible ("Salyut-6," KATE-140).

Automatic space vehicles of the "Cosmos" series are outfitted with different kinds of instrumentation for the study of natural resources. They ensure the return of the collected information to the earth in descent modules and should supply great volumes of high-quality space survey materials for use in solving numerous problems in production and science.

Space information from satellites of the "Meteor" type is transmitted to surface stations through radio channels. It is intended for study of processes and phenomena which change rapidly, for example, for prediction of weather, for detecting forest fires, for monitoring ice conditions in seas, etc.

Multipurpose scientific research work, including in the field of study of natural resources, is carried out on manned orbital stations. Cosmonauts made the first photographic surveys, including multizonal; the possibility of detecting sea and ocean currents, and also determining the bioproductivity of zones in the oceans was determined; important observations were made of the dynamics of air masses, atmospheric pollution and the effluent of industrial enterprises. New systems and technical equipment for the collection of information are being perfected and visual and visual-instrumental investigations of natural features and processes are being made. A substantial part of the working time of cosmonauts is being allocated for purely practical surveys and observations.

In necessary cases aircraft are used for additional detailed study of the features detected as a result of space sensing; in addition, synchronously with space vehicles experimental aerial surveys are being made for the testing of new methods and equipment. As a rule the experimental tests are carried out in control-measurement test ranges with the use of stationary and mobile equipment for contact and close measurements. These measurements are necessary, in turn, for study of processes of transformation of electromagnetic radiations during their propagation from an object through the atmosphere and circumterrestrial space, through radiation detectors and then to the registry system aboard the space vehicle. Such quite detailed investigations are necessary in order to study interpretation criteria of features and to develop procedures, methods and equipment for the automatic identification of remote sensing records.

Space-Earth

Today the elements of the space system for the study of natural resources and the environment, put into operation in stages, are being used in the interests of the development of our national economy, but also within the framework of international cooperation. About 300 different problems are being solved on the basis of materials from space surveys. Information from remote sensing is being used by almost 850 scientific, planning and engineering organizations. The savings for the economy resulting from the use of the new methods for the study of natural resources is many millions of rubles.

The materials from space surveys are very useful in exploration for fuel and mineral raw materials, for inventorying lands, in compiling maps of different soils and the danger of erosion, when determining the reserves of grasses in pastures, in inventorying forest resources and detecting forest damage by predators and fires, in engineering field work and the planning of major engineering structures and communication lines, for studying the danger from seismic events, mudflows and avalanches, in studying the shelf, sea and ocean currents and ice conditions in polar seas, for detecting bioproductive zones, promising regions of exploitation of fish and sea products, and for study and prediction of hydrometeorological conditions and the dynamics of natural processes, as well as for compiling and revising maps.

Now we will cite several specific examples of the practical use of space information. We will begin with the fact that space photographs are used in compiling maps of inaccessible territories in the northeastern part of the country and areas north of the polar circle, the Pamir and Tien Shan high-mountain regions, and also maps of Antarctica. This results in a substantial savings with respect to personnel and equipment and at the same time, length of time required for the work is reduced by a factor of 3-5. As a comparison we recall the heroic expeditions of Marco Polo, Semen Dezhnev, Vitus Bering, N. M. Przhevalskiy and many other explorers, geographers, navigators, topographers and geodesists. It was not easy to learn of the world surrounding us even during the first half of our century. But a survey from space makes it possible to compile maps while being tens of thousands of kilometers from the investigated territory.

Another example. In the construction of a major coal-producing complex on the basis of remote sensing materials the seismicity of the territory was determined more precisely and as a result, the cost of the initial stage of the construction alone could be reduced by 40 million rubles.

In the course of tunnel construction in a high-mountain region hot water unexpectedly spewed forth at the face under great pressure, for a long time putting an end to the tunnel construction work. Prior to the onset of construction the path of the tunnel had been studied by traditional methods and therefore, encountering the unforeseen phenomenon, engineers and miners were at a dead end. Specialists interpreted the space survey materials and ascertained that the path of the tunnel had been planned in a zone of large faults in the earth's crust which had not been detected by traditional methods and therefore it was necessary to introduce extremely significant corrections into the plans which had been drawn up on the basis of surface data.

The use of indirect interpretation criteria yields positive results in geological research. For example, in the territory adjacent to the eastern shores of the Caspian Sea the use of space photographs made it possible to detect a number of photoanomalies which could be interpreted as structures promising for the discovery of petroleum and gas. Ten of these were in sea areas with depths as great as 15 meters. About 30 major faults were discovered in this same territory. The intersections of these faults are promising for the discovery of hydrothermal deposits of polymetals.

A space survey is also being used successfully in hydrogeological research. In the semidesert region near Lake Aral the use of special indicators made it possible to detect thick lenses of fresh water in a zone of barchan sands. Drilling confirmed the results of the interpretation: water was found which was suitable for water supply to pastures.

The interpretation of space survey materials makes it possible to detect processes which transpired at the earth's surface in the remote past. For example, photographs taken from aboard the "Salyut-6" orbital station and from automatic space vehicles of the "Cosmos" series revealed the ancient delta of the Volga River and the channel of the Amu Darya. It was found that thousands of years ago the great Russian river flowed into the Caspian Sea not from

the north, as is now the case, but from the west; the Amu Darya channel migrated and during different periods was located hundreds of kilometers to the west and east of its present-day position. All this represents more than just curious facts. The data collected on the dislocation of paleochannels and paleodeltas make it possible to draw conclusions of importance to the economy. The fact is that these regions have deposits of fresh ground water at shallow depths and the exploitation of such waters in the arid steppes or in the desert zone where the mentioned paleochannels and paleodeltas are situated can be of unquestionable advantage for the development of livestock raising and oasis agriculture. In addition, information on the position of ancient watercourses can be a key to the finding of fertile soils associated with alluvial deposits.

The planned scanning of the earth's surface from orbit, comparison and analysis of materials from space surveys made during different periods, can ensure monitoring of the dynamics of natural processes and phenomena. For example, comparison of space photographs of an inaccessible mountain region taken at different times made it possible to discover a new lake which was formed as a result of melting and movements of a large glacier. An unstable natural dam could burst unexpectedly and then enormous masses of water would pour into the valley, sweeping away populated places, roads, bridges, electric power and communication lines, agricultural and industrial developments lying on its path. Measures which had been taken in time made it possible to ward off the greatest danger and not allow significant losses to the economy of this region.

Space information makes it possible to investigate relief of the sea floor, its geological structure, ranges of plants, phyto- and zooplankton, currents and water pollution... With a definite water transparency, favorable position of the sun, special choice of light filters and photosensitive materials and subsequent photochemical and optical-electronic processing it is possible to obtain photoimages of underwater relief at depths up to 30 m, and in individual cases, even more. A photographic survey on spectrozonal films clearly registers the presence of plants and plankton in the water. For example, phytoplankton containing chlorophyll and dark pigments imparts a greenish color to the water and the concentrations of phytoplankton itself can be determined from the color shade. A knowledge of color differences makes it possible to determine and outline regions which may be important for the fishing industry because fish are concentrated in places with good food reserves.

Similar examples could be given, one after the other. They have accumulated since the time when the study of the earth from space came into use in different branches of the economy. Experience in the use of space information indicates that the greatest technical and economic effect is achieved in a combined study of the natural resources of large regions. The need for carrying out such work is felt most acutely in regions where new territorial-production complexes are being established and where existing ones are being further developed. It is precisely there where wide-scale exploitation of natural wealth is being planned that it is important to make a thorough evaluation of the natural and economic potential of the territory to be exploited and to foresee its efficient utilization. This problem is being successfully solved by the methods of study of the earth from space. On the basis of surveys from space,

employing coordinated methods, at the same time with a definite degree of detail, a study is made of the earth's deep layers, plant cover, soils, hydroelectric power resources, geological engineering and agroindustrial conditions.

This sort of comprehensive inventory of natural resources, prepared as a result of such work, ensures: receipt of objective, diversified information for systematic long-range planning providing for the development of branches of the national economy within the limits of large regions; detection of unused natural resources, providing a considerable economic and social effect; systematic and effective implementation of the economic policy of the CPSU with respect to the optimal territorial organization of the economy, including thorough development of territorial-production complexes.

For example, as a result of study and mapping of the natural resources of the Tajik SSR a set of specialized maps was compiled which characterizes 30 aspects of natural resources and conditions. Unused reserves of lands suitable for cultivation and irrigation and natural grazing resources were detected. Geological formations promising with respect to the search for valuable minerals were discovered. The territory was regionalized from the point of view of seismic, mudflow and avalanche danger. The extent and characteristics of mountain glaciation were made more precise and new data have been obtained on water and hydroelectric power resources. A generalization of these results will make it possible to carry out scientifically sound planning and control of the use of natural resources.

Now it seems important, on the basis of space information, to carry out comprehensive study of natural resources in the entire country. Certification and realization of a comprehensive inventory of the natural potential of our entire country should become an important contribution of the study of the earth from space to the development of the economy. By such an inventory and regularly repeated space surveys in the immediate future it may be possible, first of all, to organize monitoring of the dynamics of natural processes, and second, to ensure the setting up of an automated system for control of the use of natural resources.



5303
CSO: 1866/37

UDC 551.524.72:551.547.5:551.593.1

# DETERMINING ATMOSPHERIC TEMPERATURE, PRESSURE PROFILES FROM MEASUREMENTS OF ASTRONOMICAL REFRACTION NEAR HORIZON

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 22, No 10, Oct 86 (manuscript received 15 Jul 85, after revision 28 Oct 85) pp 1026-1033

[Article by N.A. Vasilenko, K.P. Gaykovich and M.I. Sumin, Radio Physics Scientific Research Institute]

[Abstract] A method was proposed for retrieving the vertical profiles of atmospheric parameters from measurements of optical refraction of celestial bodies at low positive angles of elevation. The method is based completely on the results of a theoretical analysis of the problem and algorithms previously published by K.P. Gaykovich and M.I. Sumit (IZV. AN SSSR: FAO, Vol 22, No 9, 1986). Solution of the pertinent Fredholm first order integral equation is possible using two approaches: with a compact set of monotonically nonincreasing functions or by the statistical regularization method. Numerical modeling of solution of the inverse problem was carried out, as was retrieval of the profiles of atmospheric parameters. It is demonstrated that the method is highly promising for determining atmospheric stratification. A comprehensive experiment for determining refraction of celestial bodies and atmospheric meteorological parameters which involved simultaneous astronomical and aerological observations was performed in 1968 and 1972 in a slightly hilly semidesert region. Astronomical refraction was determined from the rising and setting of bright stars, planets and the sun. It is shown that the accuracy of measurements of refraction, accuracy in computing the kernel of the integral equation and the degree of correspondence of the real atmosphere to the spherically symmetric approximation used in the experiment meet all the defined requirements for the retrieval of atmospheric parameters. The accuracy is comparable to the best possible retrieval by the surface microwave radiometry method. The proposed algorithms are particularly effective when used in conjunction with the statistical regularization method. This method is highly promising, but a number of special problems remain unresolved. Figures 4; references 7: 6 Russian, 1 Western.

UDC 521.3

## POSSIBILITY OF RESTORING ATMOSPHERIC OPTICAL PARAMETERS FROM ANGULAR SATELLITE MEASUREMENT DATA

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 22, No 12, Dec 86 (manuscript received 12 Jun 85) pp 1322-1323

[Article by Ye.V. Bulychev and I.V. Mishin, All-Union Scientific-Technical Information Center]

[Abstract] A method is suggested for solving the inverse problem of restoring the optical parameters of the atmosphere based on the measured brightness field of outgoing radiation in an arbitrary interval of the optical wavelength band, based on the use of angular remote measurements and precise solutions of the boundary problems of radiation transfer theory in a plane-parallel model of the atmosphere limited by a surface with nonuniform albedo. The method suggested in the work is independent of the albedo, which is computed by inverse optical transfer operator of the atmosphere, and can therefore be recommended for processing of remote measurements regardless of the surface region involved.

UDC 528.711.1(202):330.15

## STUDY OF NATURAL RESOURCES BY USE OF SPACE TECHNOLOGY IN USSR

Moscow GEODEZIYA I KARTOGRAFIYA in Russian No 4, Apr 86 pp 11-16

[Article by Yu.P. Kiyenko]

[Abstract] The role of earth sensing from space by means of satellites is growing because of the need to efficiently find natural resources and assess their distribution. A new scientific direction--space natural history--has been developing in the USSR since the 1960's and has been raised to the level of state scientific and technical policy. Achievements to date include: 1) Development of a unified all-state policy for the development of methods and facilities for earth sensing from space. 2) Coordination and integration of the efforts of various sectors for the development of a space system for studying natural resources. 3) The formation of both scientific and industrial or specialized organization for the utilization of data obtained. 4) Development and implementation of special equipment for obtaining, processing and purposefully using space data for studying natural resources and the environment. 5) Completion of the transition from experimental and pilot studies in the use of space data to systematic studies of natural resources. It is feasible to develop a special space system for studying natural resources and the environment. This system must be permanent and multifunctional and be able to collect multipurpose interdisciplinary data intended for repeated use. It must be open-minded to allow for the

development and addition of new facilities. Development of the system must concentrate on there principal areas: the space complex; medium- and close-range sensing and direct measurements by means of aircraft, sea and ground equipment; and the reception and interpretation of data. The system presently utilizes unmanned space vehicles of the Cosmos series and Meteor type; manned orbital stations of the Salyut type and Soyuz spacecraft; airborne laboratories and helicopters; stationary and mobile land and marine facilities; a network of land and sea monitoring-and-measuring control stations for the calibration of satellite and aircraft remote sensing equipment and for the decoding of data; data receiving and processing stations; and a ramified network of users of space data. Imaging data is being used in prospecting for fuel and minerals, in land management, for soil records, for mapping agricultural land and erosion threats, for determining fodder supplies, for making timber inventories, in forest management, for identifying forest land damaged by blight and fire, for engineering studies in the planning of large construction sites; in studies of the shelf and of earthquake, torrent and avalanche hazards; studies of sea and ocean currents and of the ice situation in the polar regions; for finding promising fishing grounds; for studying and forecasting hydrometeorological conditions and the dynamics of natural processes; and for making and updating geographic maps. The oil and gas regions of West Siberia and the polar regions have been mapped by means of space image data. Space images made it possible to identify structures which are promising for oil and gas on the eastern shores of the Caspian Sea. [38-8831]

UDC 629.7:330.15

## ROLE OF MANNED FLIGHT IN STUDY OF EARTH'S NATURAL RESOURCES

Moscow GEODEZIYA I KARTOGRAFIYA in Russian No 4, Apr 86 pp 16-19

[Article by Ye.L. Lukashevich, V.A. Streltsov and A.V. Filipchenko]

[Abstract] Studies of the earth's natural resources are an important part of space program experiments. Most of the data obtained at the present time come from unmanned orbital stations, but manned stations have been playing an important and ever growing role. The kinds of problems which can be solved by means of manned systems are determined by the presence of the crew, which makes it possible to obtain creatively interpreted data, controls the system and operates and repairs instruments, and performs various operations with the remote sensing equipment. Hence, a number of problems can be solved by taking into account heightened requirements. These problems include: 1) The simultaneous creative analysis of the area surveyed and revelation of the interrelationship, interdependence and interconditionality of various phenomena and objects of the natural environment; 2) participation of the crew in development of new methods and equipment for remote sensing of the Earth; and the analysis and determination of optimal conditions for observations and imaging, in terms of time, state of the atmosphere

and illumination, for example; 3) obtaining information which is not always reflected on photographic and television images, making images under non-standard conditions, obtaining data on unpredicted, sudden phenomena, interpreting these data and quickly informing users. An important attribute of the human being is the eye-brain system, which can efficiently isolate useful data both when there is a shortage of data and when too much data are present. A human can make a preliminary analysis of the area surveyed, isolate a specific object and then make a combined visual and instrument study of it. Data can often be transferred to the user in real time. One kind of study can be substituted for another, if necessary, because of unfavorable conditons. Earth-manned vehicle interaction is possible, i.e., the mutual transfer of images, discussion of them and the making of adjustments. Specialists on earth and in space can work together directly. In the future at least one crew member will have to be a specialist in natural history with a broad background in it. Several specialists in various fields of space natural history will have to be crew members in the more distant future.
[38-8831]

UDC 528.711.1(202):543.42.062

## REMOTE SENSING OF NATURAL OBJECTS FROM SALYUT-7 STATION

Moscow GEODEZIYA I KARTOGRAFIYA in Russian No 4, Apr 86 pp 19-27

[Article by L.A. Ronzhin and Yu.L. Reshtoga]

[Abstract] A demonstration is given of the advantages of narrow-region imaging in the surveying of natural objects from outer space. The determination from space of the spectral luminosity coefficients of small objects by means of spectrometers is very difficult because of the insufficiently narrow spatial field of view and the necessity for precise orientation and stabilization. A procedure was developed for performing multizonal imaging on high-sensitivity film in the narrow regions of the spectrum (about 10 nm) in which spectrometry is performed. This technique was tested in 1985 on the Salyut-7 orbital station during its fourth expedition as part of the "Uzor" [Pattern] experiment. Images were made concomitantly with the stationary KATE-140 and MKF-6M imaging systems. A black-and-white print of a color space image of the area of the Koundradskoye cooper ore deposit is compared with a narrow-region image from the Salyut-7. The ring structures indicative of the presence of mineral deposits are much more vivid on the latter. Ring structures completely invisible or much less distinguishable in images made by the KATE-140 camera are clearly visible in narrow-region images in the 555 nm region. Measurements of the density of narrow-region negatives make it possible to dinstinguish agricultural crops. Natural objects contrast much more greatly with the background on narrow-region images made on the ground in the 548 ± 2 nm region than on images made in the 420-700 nm region. Images made by ground, aerial

photography and space systems in 15 narrow regions of the spectrum in the visible and near-IR bands have made it possible to define the optimal conditions for making images of objects important to the economy. Figures 8; references: 7 Russian.
[38-8831]

UDC 528.721.28:523.42

FEASIBILITY OF STEREOSCOPIC STUDY OF TERRAIN FROM OVERLAPPING PANORAMIC RADAR IMAGES

Moscow GEODEZIYA I KARTOGRAFIYA in Russian No 4, Apr 86 pp 27-30

[Article by Yu.S. Tyuflin]

[Abstract] Overlapping panoramic radar images were obtained with the Venera-15 and -16 space vehicles. In these panoramas images of identical points of the terrain were obtained from a particular imaging baseline. This raises the possibility of studying the relief by using the stereoscopic method. Unlike aerial photographs, where the elements of the terrain are perceived as lying in a single plane, stereoscopic panoramas are perceived as lying on a complex surface. The form of this surface depends on the imaging geometry, the space vehicle's orbit and the imaging method, i.e., on the projection used for radar panoramas and the relief. Questions are discussed relating to the stereoscopic perception of overlapping panoramic radar images for the approach to constructing panoramas used in processing the data of the radar mapping of Venus by the Venera-15 and -16. A cylindrical square equidistant projection was used. The trace of the space vehicle's orbital plane on the sphere of Venus was used as the planet's hypothetical equator. Parallax differences in the space of the stereoscopic model are calculated. The deformation of the model is determined for the case when the terrain is represented as a sphere having the radius of Venus. It is shown that elements of the relief will be stereoscopically perceived on overlapping panoramic radar images as lying on complex surfaces whose form depends both on the radius vectors of points of the terrain and on the position of sections of the terrain on the panoramic images. Figures 3; references: 3 Russian.
[38-8831]

UDC 528.711.1(202):634.0

## USE OF SPACE DATA IN FORESTRY

Moscow GEODEZIYA I KARTOGRAFIYA in Russian No 4, Apr 86 pp 30-36

[Article by V.I. Sukhikh]

[Abstract] Space data began to be used for forestry purposes more than 10 years ago. Since then an integrated aerial photography-space image system has gradually been developed and put into service for the study of forests. The following methods are now in use: photographic statistical inventory of the taiga and tundra forests of the north and northeast, and of the arboreal and shrub vegetation of the deserts of Central Asia and Kazakhstan; inventory of the little-exploited forests of the taiga region under repeated forest management; and the small-scale topical mapping of forests. The use of space imaging data has lowered costs two- to fivefold as compared with traditional methods of studying and mapping forests. The photographic statistical method was developed at the beginning of the 1980's. It utilizes high-resolution black-and-white space images obtained by Cosmos satellites and aerial photography sampling data on a scale of 1:1000 to 1:2000. In 1978-1985 this method was used for 115 million hectares of forest area, and by the year 2000 it will be used for the entire forest inventory not covered by forest management. Aerospace methods are widely used in evaluating the status of the forest inventory and monitoring changes in it. Space data from Meteor satellites have been used since 1978 to estimate the fire hazard in forests and synoptic situation and to reveal thunderclouds and convective clouds and major forest fires. A unified, integrated, multipurpose forest inventory data bank is being planned. [38-8831]

UDC 528.721.113:629.783

## RELATIONSHIP BETWEEN LINEAR ELEMENTS OF ABSOLUTE ORIENTATION OF PHOTOGRAPHS AND PARAMETERS OF SATELLITE'S MOTION

Moscow GEODEZIYA I KARTOGRAFIYA in Russian No 4, Apr 86 pp 36-39

[Article by B.I. Savelyev and Ye.A. Reshetov]

[Abstract] Analytical phototriangulation from space photographs is often the best and sometimes the only possible way of making a photographic survey of nearly inaccessible regions. The use of space image data makes it possible to use methods based on taking into account the space-time parameters of the satellite's motion. The elements of the absolute orientation of photographs can be determined in an approximation sufficient for practical purposes by finding the coordinates of the satellite's center of mass as a function of time. The latter is done by integration of sets of differential equations

describing the satellite's motion. Satellites orbiting at an altitude of 200 to 300 km are used for photographing the earth for the purpose of studying natural resources. This makes it possible to take into account the influence on the satellite's motion of just two perturbing factors: the eccentricity of the gravitational field, and the atmosphere's opposition. Differential equations are derived for the satellite's motion for the earth's normal potential. These equations are integrated for each moment of photographing, and then the coordinates of the center of projection are determined. These coordinates are the linear elements of absolute orientation of the photograph. Formulas are presented showing the relationship between these elements and the space-time parameters of the satellite's motion. The equations of motion derived for the satellite's center of mass are sufficiently accurate for determining linear elements of absolute orientation on strips several thousand kilometers long. References: 4 Russian.
[38-8831]

UDC 528.94(262.83)

DYNAMIC MAPPING OF ARAL SEA

Moscow GEODEZIYA I KARTOGRAFIYA in Russian No 4, Apr 86 pp 39-42

[Article by V.M. Sigalov]

[Abstract] Dynamic mapping makes it possible to reflect changes occurring in an area which are caused by both natural factors and man. The remote sensing of the earth's surface from space has made dynamic mapping possible. The level of the Aral Sea has been systematically dropping since 1961. Land reclamation in South Kazakhstan and Central Asia by using the water resources of the Syr Darya and Amu Darya rivers has reduced their discharge into the Aral Sea. The Syr Darya does not reach the Aral Sea at all at the present time. The position of the Aral Sea's shoreline was determined with great accuracy from space photographs taken in 1977, 1982 and 1984. These were compared with charts made in 1957-1958 when the sea had a stable level of 53 m. A chart was made of the relief of the floor from bathymetric photograph data. A map was then made of the changes in the Aral Sea from 1957 to 1984. During this period the level dropped by 10 m, the water surface area was reduced by 30 percent, and the length of the shoreline by 760 km. The volume of water was cut in half, and salinity more than doubled. The sea receded by 50 km to the east and south. Kokaral Island became a peninsula. The Akpektinskiy Archipelago was totally transformed into dry land. It had been estimated that the shoreline will drop to the 41.2-m mark by 1990. Over the last 5 years the level has dropped by 0.67 m on average per year. The current estimate is that its level will drop to the 39-m mark by 1990. By the year 2000 it will reach the 33-m mark. A further drop in level can result in salinization of part of the irrigated lands in tne region which occupy about 5.5 million hectares. These conclusions are based to a great extent on the data of space photographs. Figures 1; references: 4 Russian.
[38-8831]

UDC 528.223:550.312

# GENERAL SCHEME FOR EMPLOYMENT OF GRADIOMETRY AT SATELLITE ALTITUDES FOR DETERMINATION OF CHARACTERISTICS OF GRAVITATIONAL FIELD ON EARTH'S SURFACE

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEODEZIYA I AEROFOTOSYEMKA in Russian No 4, Jul-Aug 86 (manuscript received 9 Apr 85) pp 70-73

[Article by A.A. Dronin, candidate of physical and mathematical sciences, Moscow Order of Lenin Institute of Geodesy, Aerial Photography and Cartography Engineers]

[Abstract] The following problem is examined: In a spherical system of coordinates, the results are given of the measurement of five second derivatives of the perturbing potential at a certain set of points whose coordinates have been measured with high accuracy. The errors in measuring the derivatives are assumed to be known. The satellite's altitude varies over the range of 250 to 300 km. It is required to determine on the earth's surface the perturbing potential, T, or the values of assigned mappings onto T. The initial data are determined in a non-regular net. It takes 30 to 50 days to make the entire set of measurements, at the rate of one measurement every 10 s. In 40 days the total data number approximately $1.7 \times 10^6$. The method hitherto suggested for solving the problem reduces to the reiterated solution of a set of linear algebraic equations. The matrix of coefficients of this set of equations does not have features which make it possible to lower considerably the need for computer resources. The large number of unknowns ($2 \times 10^6$) makes the solution difficult for even the largest computers. Computations are simplified by the following approach: The data are arranged inside a hollow sphere of known dimensions. A sphere of a certain average radius is placed inside it. A "spherical prism" is assigned around each point of this net. The problem of determining the perturbing potential at a point of the net is solved by taking into account all the information present in this prism. In this way the initial information is converted into intermediate information more convenient for subsequent determination of the gravitational field on the earth's surface. Then the potential and all the necessary mappings on the earth's surface are determined from uniform data assigned in a regular net. This approach makes it possible to solve high-order sets of equations in an acceptable time on high-capacity computers of the YeS-1045 type. Tables 1; references 3: 2 Russian, 1 Western.
[39-8831]

UDC 528.715:629.78:553.982.2
550.73

# STUDY OF SPECTRAL CORRELATIONS OF VEGETATION FORMATIONS GROWING ON VARIOUS GEOLOGICAL STRUCTURES

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEODEZIYA I AEROFOTOSYEMKA in Russian No 4, Jul-Aug 86 (manuscript received 21 Nov 85) pp 88-93

[Article by N.P. Lavrova, professor, doctor of technical sciences; I.V. Almazov, docent, candidate of technical sciences; R.I. Fimin, docent, candidate of technical sciences; and V.N. Ovechkin, lecturer; Moscow Order of Lenin Institute of Geodesy, Aerial Photography and Cartography Engineers]

[Abstract] A study was conducted to investigate the variability of the spectral reflectivity of vegetation as an indicator of the presence and content of oil in an area. Even a slight increase or decrease in chlorophyll in leaves causes a change in their spectral reflectivity, and this is most pronounced in the blue-green and red regions of the spectrum. The quantity of green pigment in plants is strongly related to how much nitrogen, potassium and sulfur they contain. Underground deposits of oil cause the surface layer of soil to be enriched with various compounds which find their way into plants. By measuring the spectral reflectivity of vegetation and wood species, such as pine, growing under identical natural conditions in reference oil-bearing and non-oil-bearing sections, it is possible to identify sections of oil concentration under identical conditions of observation. The study included the following steps: 1) Aerial photography of landscapes of the same type distinguished by their oil content. 2) Photographic and microphotographic analysis of photographic mission results. 3) Statistical processing of initial data on a computer. 4) Quantitative assessment of processing results. Geological structures in Tyumen Oblast which had previously been identified as oil-bearing were selected for correlation purposes. An A-39 aerial camera was used, with ZHS-18 and OS-14 interchangeable light filters and type 22 isopanchrome film. The negatives were processed in an IFO-451 microphotometer having a 20 x 30-micrometer scanning aperture. Microphotometric sectional views were obtained in the form of density curves, recorded on a chart strip, for the black areas on the negative scanned by the photometer. Statistical processing was performed in order to verify the possibility of determining the oil content factor from the discrete brightness structure of the subject. A quantitative estimate was made of the probability of the identification of oil content factors from averaged statistics on the brightness field of the subject photographed. Relative identification of the oil content factor with accuracy of on the order of 1 percent is possible with two-region photographing; multiregion photographing is necessary for absolute identification. Tables 2; references: 2 Russian.
[39-8831]

UDC 528.77

# FEATURES OF DECODING OF SPACE PHOTOGRAPHS OF SEASHORES WITH SURGE-AND-WASH PHENOMENA

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEODEZIYA I AEROFOTOSYEMKA in Russian No 4, Jul-Aug 86 (manuscript received 6 Dec 85) pp 93-96

[Article by T.V. Vereshchaka, docent, candidate of geographical sciences, Moscow Order of Lenin Institute of Geodesy, Aerial Photography and Cartography Engineers; G.F. Krasnozhon, candidate of geographical sciences, and I.Ye. Kurbatova, engineer, USSR Institute of Water Problems]

[Abstract] The geography of seashores varies over time because of complex perennial and seasonal ebb-and-flow fluctuations in level and surge-and-wash fluctuations in level on account of wind action. The level of the Caspian Sea dropped more than 3 meters over the past 50 years, but it has been gradually rising since the end of the 1970's. The North Caspian Sea was photographed from space in various seasons during 1973-1983 in order to study dynamic phenomena on its shores, with emphasis on the extremes of the position of its shoreline and the resulting agricultural impact. More than 100 space photographs were analyzed. Images obtained during spring high water, reflecting maximum inundation of the shores during washes, and during fall low water were the most informative. The shores of the area studied are characterized by two different-age bench terraces which show clearly on black-and-white and color spectrozonal photographs. The lower terrace is influenced by surge-and-wash processes and contains today's shoreline. A 1-cm change in the North Caspian's level involves a 100- to 120-m change in the position of its shoreline, and strong winds can shift the shoreline 15 to 20 km. The decoding of images is hence a complex process, further complicated by the poor contrast of the dry land-water boundary because of the low slope of the floor. The scale and resolution of the photographs made it possible to record 200- to 500-m changes in the position of the shoreline and to prepare unique charts of shores inundated by washes for an integrated characterization of wash phenomena and their influence on nature and the territory's economy. Space photographs had the advantage of obtaining synchronous hydrological data and reflecting the state of dynamic phenomena over a large territory at a single specific point in time.
References: 5 Russian.
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## SPACE POLICY AND ADMINISTRATION

### SOVIET OFFICIALS DISCUSS COMMERCIAL SPACE SERVICES OFFERED BY USSR

Moscow LENINSKOYE ZNAMYA in Russian 14 Dec 86 p 4

[Abstract] The article is an interview with A.I. Dunayev, head of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research (Glavkosmos), and I.D. Alekseyev, director of the transportation equipment licensing firm "Litsenztransmash", regarding plans to offer a variety of space transportation services on the world commercial market. "Litsenztransmash" is acting as agent for Glavkosmos' services in this market.

Dunayev said that Glavkosmos can launch communications, weather or geodetic satellites into any desired orbits for foreign companies, and also control them in orbit and handle the receiving and processing of information. Another service offered is testing of instruments and devices built by foreign organizations on board Soviet spacecraft. Dunayev said that Glavkosmos is prepared to conduct experiments and research proposed by foreign organizations on board Soviet space stations, and to conduct geodetic and geological surveying of national territories. It is also hoped that contracts can be made for joint development of new commercial equipment, for example, for production of materials for electronics.

Asked what services his licensing firm is offering at present, Alekseyev named three: placing foreign satellites into orbit, including geostationary orbits, with Soviet launch vehicles; launching of Soviet satellites, such as those of the "Gorizont" type, and turning them over, either in whole or individual relay transmitters on them, to foreign clients, on a straight purchase or leasing basis (the client also is offered the use of Soviet ground receiving and transmitting facilities for communications with satellites); and carrying of foreign instrument packages on Soviet satellites and interplanetary probes. Alekseyev said that negotiations are under way with a number of international organizations and also with national and private companies of capitalist countries. For example, at a meeting of the Inmarsat organization in Kyoto in November, Glavkosmos made an offer to orbit a second-generation Marex satellite of this organization.

Dunayev and Alekseyev emphasized the reliability of the Soviet space launch system. They noted that because of recent accidents with the Challenger spaceship and Delta, Titan and Ariane launch vehicles, rising insurance rates

have pushed up the price of their operators' delivery services. On the other hand, they claimed that there has not been a single failure in the last 35 launches of the Soviet "Proton" launch vehicle, and added that the Soviet insurance company "Ingosstrakh" offers very reasonable rates. Dunayev cited capabilities of the "Proton": delivery of more than 20 tons of payload into low orbits of 200 kilometers, and of 2 tons into geostationary orbits. With the "Proton", he said a station weighing 5.7 tons can be sent to the moon, 5.3 tons to Venus, and 4.6 tons to Mars.

Asked about foreign press reports that there is reluctance to deal with the USSR for fear of giving Soviet specialists access to the latest Western technology, Alekseyev said this was a trumped-up claim. He said their negotiations with foreign clients always include mutual understanding on protecting design and technological secrets. He said any reasonable measures can be agreed on, even having a special group accompany a satellite to ensure that it is not touched during the whole time it is on Soviet territory.

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## DUNAYEV CLAIMS U.S. EMBARGO BLOCKING INTERNATIONAL COOPERATION IN SPACE

Moscow EKONOMICHESKAYA GAZETA in Russian No 10, Mar 87 p 20

[Abstract] The article is a full-page interview with Aleksandr Ivanovich Dunayev, head of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research (Glavkosmos). He answered questions about space transport and technology services that the USSR is making available on a commercial basis to foreign firms and organizations.

Dunayev briefly described the services the USSR is offering, such as launching communications satellites and organizing satellite information gathering for natural-resource studies of territories of other countries. He noted that the USSR already has orbited 30 satellites for other countries, including India, France and Czechoslovakia. At the present time, preparations reportedly are in progress for launching another Indian satellite, which will be used for sensing the national territory of India. In January, Soviet specialists went to India to help prepare the satellite, which is to be launched from Baykonur in September or October.

Dunayev said that Glavkosmos had been approached by organizations in the USA and Great Britain which were interested in having satellites orbited for commercial and scientific purposes. He said agreements could not be concluded because of the U.S. Government's strict embargo on shipment to the USSR of any space equipment containing U.S.-made components. Dunayev said this was despite Soviet assurances that satellites can be exempted from customs inspections, and can be delivered to the launch site in sealed containers while being accompanied all the way by their owners. Saying this proves the groundlessness of the U.S. Administration's claim that the embargo safeguards U.S. technological secrets, Dunayev remarked:

"From all appearances, the question here does not involve technology, but politics. Militant, pathological anticommunism is striving with all its power to prevent peaceful cooperation of nations in space. This embargo is not aimed against the USSR, but is primarily against those states, organizations and firms that do not have their own space technology. I'll cite just one example. The organization 'Inmarsat' is ready to sign, together with USSR Glavkosmos, an agreement to have a Soviet launch rocket orbit a satellite for communications with vessels sailing the world's oceans. But

the intransigent position of the White House is keeping this mutually advantageous project from being carried out."

Dunayev also said that the orbiting scientific station "Mir" presents great prospects for broad international cooperation, with its capability of having several scientific modules docked with it. He said already Glavkosmos is able to accept instrument packages from other countries for conducting technological experiments on "Mir", and that if the scope of proposed experiments warrants it, entire modules might be made available to foreign organizations.

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## BRAZILIAN SCIENTISTS JOIN INTERCOSMOS

Leningrad LENINGRADSKAYA PRAVDA in Russian 8 Feb 87 p 3

[Text] Scientists of Brazil have joined the large body of specialists of many countries who are pooling their efforts in peaceful exploration of space under the flags of the "Interkosmos" council of the USSR Academy of Sciences. This was the result of the first visit to Moscow by a group of scientists from Brazil's Space Research Institute, which ended 6 February.

Marco Raupp, the institute's general director, expressed satisfaction with the negotiations that took place at Soviet research centers, calling these meetings a fruitful beginning for the cooperation between the USSR and Brazil in space orbits.

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## NEW BOOK ON CAREER OF S.P. KOROLEV

Moscow PRAVDA in Russian 12 Jan 87 p 3

[Abstract] The lengthy article announces a new book entitled "Academician S.P. Korolev as a Scientist, an Engineer, and a Person (Akademik S.P. Korolev. Uchenyy. Inzhener. Chelovek)," which has been published by "Nauka" on the occasion of the 80th anniversary of Korolev's birth. The book consists of reminiscences of Korolev and of working with him by more than a hundred scientists, engineers, physicians, Communist Party functionaries, common workers and other persons. The compiling editor of the collection is Doctor of Technical Sciences G. Vetrov, and members of the editorial board of the publication included A. Tshlinskiy, B. Raushenbakh, V. Barmin and V. Mishin.

The article contains excerpts from the book by the following persons: V. Chernov, G. Maksimov, G. Vetrov, A. Voltsifin, I. Firsov, S. Denisov, V. Karin, S. Okhapkin, V. Syromyatnikov, V. Rozhkov, G. Grechko, V. Zudanov and M. Gallay.

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## RAUSHENBAKH RECALLS KOROLEV, ARREST NOTED

Moscow IZVESTIYA in Russian 11 Jan 87 p 3

[Article by Ye. Manucharova (interviewer)]

[Abstract] The article is a lengthy interview with Academician Boris Viktorovich Raushenbakh on the occasion of the 80th anniversary of the birth of Sergey Pavlovich Korolev. Raushenbakh talked about his life-long friendship with Korolev and their work together in the space program. Raushenbakh, who was in charge of work on controlling spacecraft, recalled in particular a problem with the "Voskhod-2" spacecraft and consultations Korolev had with Yuriy Gagarin, who was serving as controller of the mission.

At the end of the interview, Raushenbakh described how Korolev was a strongly goal-oriented person, through the period when he organized the jet propulsion research group (GIRD) and later worked at the Jet Propulsion Scientific Research Institute. Raushenbakh remarked that Korolev was working on a project to send a manned rocket into the stratosphere when this work was "tragically interrupted." At this point of the interview, the interviewer interjected that there was no need to speak in "allegorical terms," that it was no secret that Korolev was arrested as a result of false testimony against him by an informer. The interviewer added that although Korolev eventually was allowed to return to continue his work, the charges against him were not repealed for a long time.

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## PROFILE OF A.S. KIRILLOV, FIRST HEAD OF LAUNCH SERVICES AT BAYKONUR

Moscow KRASNAYA ZVEZDA in Russian 17 Jan 87 p 4

[Article by V. Nagornyy, correspondent]

[Abstract] The lengthy article traces the career of Anatoliy Semenovich Kirillov, who was head of the launch service of the Baykonur Cosmodrome during the first eight flights of manned spaceships. It tells about Kirillov's association with Sergey Pavlovich Korolev and other figures of the early space program. Kirillov came to Baykonur when it was first being built. He had served as commander of a katyusha rocket battery during the war, and after the war he graduated from the higher educational institution that was the chief rocketry school. He was invited to work at Baykonur by Aleksey Ivanovich Nesterenko.

In conclusion the article reports that Kirillov is still working, as senior science associate at the Moscow Aviation Technology Institute. He reportedly is preparing a course for aircraft testing technology.

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## FIRST CONGRESS OF USSR COSMONAUTICS FEDERATION

Moscow MOSKOVSKAYA PRAVDA in Russian 18 Jan 87 p 2

[Excerpt] Cosmonautics has become a leading branch of science and technology and a factor that determines the level of a society's culture. This is obviously confirmed by the array of participants of the first congress of the USSR Cosmonautics Federation, which opened in the capital on 17 January. Among the delegates to this congress are veterans of space science and technology, prominent Soviet scientists and designers, pilot-cosmonauts, representatives of museums, writers and journalists.

USSR pilot-cosmonaut N. Rukavishnikov, chairman of the federation, gave its summary report, which presented a broad picture of this mass public organization's work on publicizing achievements of Soviet and world cosmonautics and attracting school children and other youth to this field of learning. The federation's main tasks include actively promoting the acceleration of scientific-technical progress in the field of cosmonautics, developing the creative activity of workers in this field, and furthering, in every way possible, introduction of results of space research into various branches of the country's economy.

The report emphasized that the USSR Cosmonautics Federation will strengthen its efforts aimed at developing international cooperation with the scientific and engineering communities of other countries and take an active part in the work of international organizations.

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## CONTRIBUTIONS OF M. V. KELDYSH TO COSMONAUTICS

Moscow ZEMLYA I VSELENNAYA in Russian No 4, Jul-Aug 86 pp 65-71

[Article by V. S. Avduyevskiy, academician: "Outstanding Theoretician in Cosmonautics (75th Anniversary of Birth of M. V. Keldysh)"]

[Text] Five years have elapsed since we commemorated the 70th anniversary of the birth of M. V. Keldysh. During this time work has been initiated on a collection of selected writings of the scientist which is now nearing completion.

Academician M. V. Keldysh (1911-1978)

Familiarization with his writings, collected together, will again afford an opportunity to see and comprehend better what an unusual man Mstislav Vsevolodovich Keldysh was, what an exceptional scientist and organizer of science, thinker and humanist he was. He enriched science with fundamental studies in the fields of mathematics, mechanics, aviation and cosmonautics. M. V. Keldysh made a particularly great contribution to the mastery of space. He stood at the threshold of a magnificent achievement -- man's emergence into space -- and has always remained in our memory as the "Chief Theoretician of Cosmonautics."

M. V. Keldysh entered the field of rocket-space technology in 1946, heading the scientific research institute in which the famous "guards mortar" (rocket launcher) was developed before the war. Strong teams of scientists and specialists having experience in developing models of controllable ballistic rockets and rocket aircraft worked at the scientific research institute.

M. V. Keldysh, 35 years of age, just elected an academician, superbly analyzed the problems facing the Soviet aviation industry and had a splendid scientific and theoretical preparation. The bringing together of his knowledge and the many years of practical experience of the institute staff was to favor an intensification of research in the field of jet flights and determination of new approaches in the development of rocket technology.

While heading the scientific research institute, M. V. Keldysh continued with the work which he had already begun in 1935 at the Mathematics Institute imeni V. A. Steklov, USSR Academy of Sciences. Later this work became the theoretical basis for introduction of mathematical computation methods with use of an electronic computer in different branches of technology.

Mstislav Vsevolodovich immediately won enormous prestige among the specialists of the scientific research institute. His great erudition, accuracy in formulating problems, capability for instantly getting to the heart of a problem and evaluating the prospects for success in the work, calm manner, ability to listen, and in general his high level of culture, all this brought respect for and trust in him on the part of institute personnel.

The range of scientific problems being solved at that time at the scientific research institute was determined by the problems involved in the development of jet flights. They were concentrated in two principal directions that seemed most promising. One of them was the development of aircraft outfitted with supersonic ramjet engines and the other was the development of rocket technology and cosmonautics.

Under the direction of Mstislav Vsevolodovich work was done at the institute on the theory of jet engines of different designs, the theory of combustion, gas dynamics and chemical thermodynamics. M. V. Keldysh looked far ahead and although flights at great supersonic speeds at that time seemed to be too far in the future or even a dream, in the institute laboratories hypersonic wind tunnels with flow velocities 6-8 times greater than the speed of sound were constructed, as well as high-temperature heaters of different type. A general theory of ramjet engines was "born" within the walls of the

scientific research institute; supersonic air intakes were designed and experimentally investigated; theoretical research on combustion in combustion chambers was carried out and practical work in this direction was done. During 1949-1950 institute specialists constructed a working experimental model of a flightcraft with a ramjet engine which for the first time in our country attained a flight speed exceeding the speed of sound by a factor of 2.7.

Academicians M. V. Keldysh and S. P. Korolev.

At the same time theoretical studies in the fields of rocket dynamics and mechanics of spaceflight were developed in the Department of Applied Mathematics in the Mathematics Institute imeni V. A. Steklov under the direction of M. V. Keldysh. These studies exerted a great influence on the development of rocket-space technology. During 1949-1951 a series of studies was carried out for determining the optimal designs and characteristics of multistage rockets. Also very important were computations of rocket rotation about its center of mass, taking into account the mobility of the liquid having a free surface in the rocket tanks. In addition, a study was made of the possibility of ballistic descent of space vehicles from orbit to earth, which served as a basis for constructing working descent vehicles. The first specific variant of a gravitational stabilization system for artificial earth satellites was

proposed and a theory of such stabilization was formulated.

This is far from a complete enumeration of the research which was directed by M. V. Keldysh at that time.

He also played a major role in the holding of scientific seminars with a discussion of the most fundamental and important subjects. Appearance at such a seminar became an event for each scientific worker, regardless of his assignment, knowledge or academic degree. The work and proposals were always examined at the seminar objectively and, I might say, mercilessly. Frequently Mstislav Vsevolodovich, discovering an error in the reasoning of a speaker, himself found a true solution; rapidly making an entire analysis in his mind, he indicated an approach differing very greatly from that proposed by the author. At the seminars, in addition to theoretical questions, there was discussion of technical ideas without an evaluation of their practical significance.

M. V. Keldysh placed high demands on himself and others and had no tolerance for idle words and dilettantism. A profoundly intelligent man, he never abused anyone verbally and did not even raise his voice. However, his word was always decisive and his instructions were carried out without challenge.

An important phase in the life of M. V. Keldysh was his joint work and friendship with the famous aircraft designer S. A. Lavochkin. This cooperation began in the early 1950's when both advanced the idea of a supersonic aircraft. This continued up to the untimely death of S. A. Lavochkin in 1960. Their creative alliance was marked by outstanding scientific and technical achievements which laid the basis for the movement of aircraft at great supersonic speeds. For the first time it was possible to investigate the operation of a ramjet engine and to solve the problem of protection of the flightcraft and its systems against aerodynamic heating. The theoretical basis was laid for astronavigation and astrocorrection systems for flight control and these were constructed under the direction of M. V. Keldysh. Mstislav Vsevolodovich and his associates for the first time in our country developed the logic of such systems with their subsequent technical embodiment and flight tests. These investigations in many respects served as a scientific basis for constructing systems for control of space vehicles with astrocorrection.

Designated as scientific director of the entire program, M. V. Keldysh assumed total responsibility for the scientific and technical level of the constructed flightcraft and for seeing the work through to the end by the stipulated target dates. Quite frequently in the course of the work design problems were intertwined with fundamentally new scientific problems. M. V. Keldysh could for entire days discuss the difficulties which were arising with various "narrow" specialists until the correct solutions were found.

During this same period the creative alliance of M. V. Keldysh and S. P. Korolev began to develop. Korolev, in 1946, was designated Chief Designer of Rockets. These noteworthy men -- designer and scientist -- were joined together not only by a common task, but also by real friendship. The alliance of men who in the history of USSR cosmonautics have received the honorary

titles of "Chief Designer of Cosmonautics" and "Chief Theoretician of Cosmonautics," to a high degree facilitated the grandiose successes which marked the beginning of the space era.

Already in 1953, when the vigorous development of long-range missiles was taking place in our country, it became evident that it was possible to attain first cosmic velocity and put an artificial earth satellite into orbit. And in actuality, very soon, on 4 October 1957, the first artificial earth satellite was launched in the Soviet Union. Cosmonautics became a reality. A period of gigantic work on the winning of space began.

The entire range of scientific investigations directed to the mastery of space had to be integrated into a harmonious whole. And this required that this undertaking be headed by a leading scientist very familiar with both the new technology and with the capabilities of industry, a scientist with broad vision, having the ability to dream and capable of seeing the real way to solve the most difficult problems. M. V. Keldysh was precisely such a scientist.

The development of the Soviet space program began under his direction even before the launching of the artificial earth satellite. For this purpose M. V. Keldysh attracted leading scientists from different branches of science. Mstislav Vsevolodovich achieved such a structure of the program that it made possible simultaneous solution of specific fundamental scientific or practical problems and did not consist simply of a set of interesting but scattered experiments. As a result, the program included a whole range of studies in a new research field -- exoatmospheric astronomy, study of the upper atmosphere and physics of circumterrestrial space. M. V. Keldysh and S. P. Korolev had a special role in study of the planets using scientific space probes.

Mstislav Vsevolodovich was one of the first to comprehend the importance of artificial earth satellites for organizing communication systems and systems for global observation of the earth's surface, observation of the earth's natural resources, for geology, geography and meteorology. He stated that these functions of space vehicles soon would become exceedingly important from the point of view of science and the economy. In this connection M. V. Keldysh gave great support to the personnel of the design bureau headed by the well-known designer M. K. Yangel. It was precisely there where specialists developed the massive expensive rockets and space vehicles which were used in investigations of the upper atmosphere and circumterrestrial space under the "Cosmos" and "Intercosmos" programs.

In 1961 M. V. Keldysh was elected president of the USSR Academy of Sciences and began to carry out an enormous amount of work on the coordination of all fundamental research in the country carried out in the field of natural and social sciences. With his characteristic consistency M. V. Keldysh concentrated his main efforts on working out a proper strategy for scientific research and choice of the main directions in science favoring the acceleration of scientific and technical progress. Having much practical experience in work in aviation, the atomic industry and in the field of rocket-space technology, he clearly understood the need for the further development of the fundamental

sciences. At the Plenary Session of the CPSU Central Committee in November 1962 M. V. Keldysh defined those fields of science which should exert the greatest influence on the economy. These included power production, obtaining new materials, including polymer and ultrapure semiconductors and the development of computers. In his numerous addresses he repeatedly emphasized the importance of development of cybernetics, the need for developing new mathematical methods and mathematical machines for scientific research, the development of scientific information and automation of production. He indicated that scientific and technical progress is determined not only by the successes of science itself, but also the effective application of scientific advances in practical work.

The brilliant and meaningful speeches of Mstislav Vsevolodovich even now have importance and timeliness and his profound thoughts concerning the general development of science published recently in the volume IZBRANNYYE TRUDY M. V. KELDYSHA (Selected Writings of M. V. Keldysh) have already entered into the "treasury" of world science.

Despite his great work load at the Academy, Mstislav Vsevolodovich did not abandon his favorite subject: cosmonautics. His role in implementation of the USSR space program increased still more. The Applied Mathematics Institute, USSR Academy of Sciences, which now is named in honor of Keldysh, was established in 1963 on the basis of the Applied Mathematics Department of the Mathematics Institute imeni V. A. Steklov. The research carried out at the institute under the direction of M. V. Keldysh served as a basis for the ballistic support of space flights. The Space Research Institute was established in 1965 on the proposal of Mstislav Vsevolodovich. It is now the key, coordinating institute of the USSR Academy of Sciences concerned with space research.

In his position as director of national space programs the consistency and persistence of Mstislav Vsevolodovich in achieving an intended goal, his striving to see things through to the end, as he said, "without wavering," and resolution of any formulated problem were manifested to the fullest degree

Under his direct leadership the teams of scientists from academic and branch institutes, together with the team headed by the superb designer G. N. Babikin, formulated a long-range program for study of the moon and planets. As a result of implementation of this program information was obtained on the Moon, Venus and Mars which was invaluable for science.

That was a period when reality outpaced dreams. The results of the work carried out at that time constituted an enormous contribution to science. It reinforced the leading role of the Soviet Union in the study of the moon and planets and still further raised the prestige of our country. The exploration of the planet Venus can serve as a clear example of this. In 1967 the "Venera-4" descent module entered the Venusian atmosphere and below the cloud layer, descending by parachute, executed the planned measurements. Soon thereafter Mstislav Vsevolodovich held several scientific seminars at which all participants in the experiment gave presentations. Former concepts concerning Venus were completely overturned. It became clear that Venus has a thick atmosphere of carbon dioxide and that the cloud layer has a very great vertical extent; at the planetary surface atmospheric pressure is equal to amost 100 atm; temperature is $\sim$ 500°C.

The "Venera-8," descending on the planetary "crescent" visible from the earth, for the first time measured illumination at the surface. Subsequent descent modules of new "Venera" generations transmitted photo- and television panoramas of the surface to receiving stations via the artificial satellites of Venus, investigated clouds consisting of sulfur compounds, studied composition of the surface material and obtained radar maps of a great sector of the planet.

In one of his last addresses in April 1978 M. V. Keldysh emphasized that a knowledge of planetary systems is a major undertaking of an ideological character whose solution will strengthen the basis of materialistic knowledge.

Without in any way detracting from the enormous importance of automatic spacecraft for the economy and science, S. P. Korolev and M. V. Keldysh at the same time regarded the main objective of cosmonautics to be the development of manned vehicles and man's mastery of space.

M. V. Keldysh stated that penetration into space is exerting an enormous influence on the outlook of modern man. Mankind no longer feels itself to be restricted to the limits of his planet. Emerging into space, he is afforded the new possibility for viewing the earth, as it were, from the outside. The development of cosmonautics thereby not only favors the development of science, but also increases the responsibility of people for the fate of our planet.

Mstislav Vsevolodovich clearly visualized the role of man in the practical mastery of space, in conducting research, collecting and assembly of components in open space and in accomplishing preventive repair work in orbit. He devoted particular attention to life support problems, biomedical research and safety problems. It was this initiative of S. P. Korolov and M. V. Keldysh which was responsible for the organization of a service for the radiation monitoring of space, the establishment of a special Biomedical Problems Institute and the Cosmonaut Training Center.

On 12 April 1961, for the first time in history, a citizen of the USSR, Yu. A. Gagarin, in the "Vostok" spaceship made an orbital flight around the earth. Remarkable prospects for man's mastery of space had appeared.

M. V. Keldysh played an enormous role in the realization of the subsequent manned flight program. He stated that thereafter the docking of spaceships in orbit and the construction of orbital stations were becoming a reality and that scientists in the most different fields of specialization would begin to work beyond the earth in the not distant future.

The first docking of "Soyuz" manned vehicles took place on 16 January 1969. At a press conference devoted to this flight Mstislav Vsevolodovich emphasized the importance of constructing permanently operating manned stations and noted that the successful docking of the "Soyuz-4" and "Soyuz-5" ships was a major step forward in the supplying of such stations.

And soon thereafter, in 1971, the first "Salyut" station began its flight in circumterrestrial orbit. Since that time complexes including the "Salyut"

stations and the "Soyuz" transport ships have been successfully functioning in space. Comfortable conditions have been created on them for prolonged work, for conducting scientific research, for the rest of the crew and for performing physical exercises. It was demonstrated that there was a possibility for prolonged presence and effective work of cosmonauts on an orbital station and unique scientific results were obtained. A great amount of repair and assembly work was done in open space. Due to the flights of these space complexes a major step was taken in the development of space machine building, a step in the direction of the industrialization of space.

Cosmonautics became a branch of the economy. Mstislav Vsevolodovich always was excited as to how best apply the advances in cosmonautics for practical purposes. He devoted great attention to space technology, the use of space conditions for obtaining materials with improved properties. He was also concerned with matters related to the use of remote sensing methods -- an important help in the development of agriculture and forestry, meteorology, hydrology, oceanography and preservation of the environment. He constantly worked for more effective use of data on natural resources obtained from satellites and achieved an orderly organization of the system for the dissemination of the corresponding information to interested ministries and departments.

Being in the position of president of the Academy of Sciences, M. V. Keldysh in every way possible facilitated the development of international cooperation in the solution of problems shared by all mankind. He understood that such cooperation favors the relaxation of tension in international relations and is in the interest of peace. M. V. Keldysh became one of the initiators in establishing the "Intercosmos" Council, facilitated the conclusion of an agreement between the USSR and the United States on execution of the joint experimental "Soyuz-Apollo" flight and made a major contribution to the organization and successful implementation of this flight.

Mstislav Vsevolodovich was convinced: space should be used only for peaceful purposes. Already in 1962, speaking at a Soviet Social Life Conference and at the Work Congress on Disarmament and Peace, he warned against nuclear explosions in circumterrestrial orbit. M. V. Keldysh indicated that these explosions would lead to the impairment of a complex group of geophysical phenomena in circumterrestrial space and in the upper layers of the atmosphere and could exert an influence on the conditions for life on the earth. Mstislav Vsevolodovich called upon all scientists and all progressive people on the earth to fight for a peaceful space, total disarmament and the banning of nuclear tests. He clearly understood the danger of use of scientific advances for military purposes, leading to the appearance of an enormous potential for death and destruction. In one of his addresses Mstislav Vsevolodovich quoted from a play by Bertolt Brecht, who put in the mouth of his hero -- Galileo -- the following wise words: "The sole purpose of science is to assist in the difficult human existence. And if scientists, intimidated by self-willed masters, are content with the accumulation of knowledge for the sake of knowledge, their advance in science will be remote from mankind and one fine day the triumphant outcry about a new discovery will be met with a terrified

response." It is an irony of fate that the "Life of Galileo" was presented in the United States precisely at the time when American aircraft had subjected Hiroshima and Nagasaki to atomic bombardment.

The appeal to scientists of the entire world not to allow the results of their work to be used to the harm of mankind sounds particularly timely today. In space there is no room for death-dealing weapons intended for the waging of "star wars." Right now there is time, uniting the forces of all people of good will, to forestall the catastrophe being readied by the militaristic circles in the United States. M. V. Keldysh untiringly fought for the strengthening of international relations among scientists, for the relaxation of international tension and peace. Space should be a zone of peace, a zone of uniting the efforts of mankind in learning the secrets of the universe, such are the ideas of M. V. Keldysh which are now becoming a slogan for all progressively thinking people of our planet.

M. V. Keldysh can rightfully be called one of the outstanding scientists of modern times. He is a brilliant representative of world science of the 20th century, the founder of a great scientific school, the creator of new directions in applied mathematics, aerodynamics and space technology. In the history of cosmonautics the name Mstislav Vsevolodovich Keldysh will always stand alongside the names of Konstantin Eduardovich Tsiolkovskiy and Sergey Pavlovich Korolev.



5303
CSO: 1866/37

LAUNCH TABLE

LIST OF RECENT SOVIET SPACE LAUNCHES

Moscow TASS in English or Russian various dates

[Summary]

| Date | Designation | Orbital Parameters | | | |
|---|---|---|---|---|---|
| | | Apogee | Perigee | Period | Inclination |
| 5 Jan 87 | Meteor-2 | 973 km | 950 km | 104 min | 82.5° |
| | | (Meteorological satellite; carries equipment for global imagery of clouds and underlying surface in visible and IR ranges; memory storage and direct transmission modes; also has equipment for continuous observation of penetrating radiation in near-Earth space; data goes to State Center for Study of Natural Resources and State Committee for Hydrometeorology) | | | |
| 9 Jan 87 | Cosmos-1811 | 367 km | 181 km | 89.7 min | 55° |
| 14 Jan 87 | Cosmos-1812 | 677 km | 648 km | 97.8 min | 82.5° |
| 15 Jan 87 | Cosmos-1813 | 387 km | 208 km | 90 min | 72.8° |
| 16 Jan 87 | Progress-27 | 280 km | 189 km | 88.9 min | 51.6° |
| | | (To deliver expendable materials and cargo to the unmanned Mir station) | | | |
| 21 Jan 87 | Cosmos-1814 | 815 km | 775 km | 100.7 min | 74° |
| 22 Jan 87 | Cosmos-1815 | 558 km | 345 km | 93.5 min | 50.7° |
| 22 Jan 87 | Molniya-3 | 40,800 km | 473 km | 12 hrs 16 min | 62.8° |
| | | (Communications satellite for long-distance telephone, telegraph and radio communications and broadcast of USSR Central TV to points in the "Orbita" network) | | | |

| Date | Designation | Orbital Parameters | | | |
|---|---|---|---|---|---|
| | | Apogee | Perigee | Period | Inclination |
| 29 Jan 87 | Cosmos-1816 | 1,024 km | 979 km | 104.9 min | 82.9° |
| 30 Jan 87 | Cosmos-1817 | 224 km | 192 km | 88.4 min | 51.6° |
| 2 Feb 87 | Cosmos-1818 | 810 km | 790 km | 100.7 min | 65° |
| 7 Feb 87 | Cosmos-1819 | 254 km | 197 km | 88.7 min | 72.8° |
| 14 Feb 87 | Cosmos-1820 | 273.2 km | 185.9 km | 88.8 min | 64.8° |
| 18 Feb 87 | Cosmos-1821 | 1,029 km | 983 km | 105 min | 82.9° |
| 19 Feb 87 | Cosmos-1822 | 331.5 km | 205 km | 89.5 min | 73° |
| 20 Feb 87 | Cosmos-1823 | 1,538 km | 1,497 km | 116 min | 73.6° |
| 26 Feb 87 | Cosmos-1824 | 370 km | 177 km | 89.7 min | 67.2° |
| 3 Mar 87 | Cosmos-1825 | 677 km | 649 km | 97.7 min | 82.5° |
| 3 Mar 87 | Progress-28 | 272 km | 191 km | 88.8 min | 51.6° |
| 11 Mar 87 | Cosmos-1826 | 403 km | 206 km | 90.3 min | 72.9° |
| 13 Mar 87 | Cosmos-1827 -- Cosmos-1832 | 1,442 km | 1,400 km | 113.9 min | 82.6° |
| | | (Six satellites orbited by single launcher) | | | |
| 18 Mar 87 | Cosmos-1833 | 878 km | 851 km | 101.9 min | 71° |
| 19 Mar 87 | Raduga | 35,967 km | -- | 24 hrs 05 min | 1.3° |
| | | (Communications satellite for telephone, telegraph and radio and for transmission of TV programs; near-stationary, circular orbit) | | | |

CSO: 1866/63

END

# END OF FICHE

# DATE FILMED

July 24, 1987